POWER PLANT ENGINEERING

Established Over 28 Years

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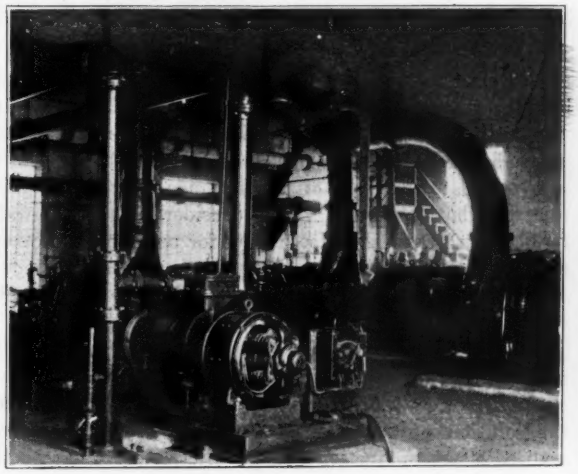


3000 Turbine Horsepower from Steel Chips

WOULD a 15 per cent drop in capacity on a new power unit cause you worry? This recently took place on a new 20,000-kw. unit after it had been in operation but a few days. Examination showed that iron and steel chips, carried from the piping by the steam, had cut and battered the first wheel buckets and the nozzles. This is but one instance of the far-reaching and serious effects which improper piping conditions may bring about in the power plant. Many valuable pointers on the proper installation of piping will be found in an article in this issue entitled Pipe Connections for Power Units.

SUPPOSE some fine morning when you are feeling particularly satisfied with yourself, the "Old man" comes in and leads you to a large motor out on the shipping platform. "Jim," he says, or "Charley"—whatever you call yourself—"here is that synchronous motor we bought second-hand the other day. These 12 wires are the terminals of the windings. Now, we don't know a blamed thing about the machine so I want you to find out how it is wound and how to connect it for proper operation. Here is a voltmeter, now go to it!"

Suppose *you* were in a fix like that with only a little voltmeter to help you, would your sunny disposition leave you flat or would you know how to go about the job? If you don't just follow the directions given by Mr. Caparo on page 1101.

New Vacuum Oil Co. Plant at Olean, N. Y., Illustrates Refinery Practice

CENTRAL BOILER PLANT WITH 5341-HP. CAPACITY DISTRIBUTES STEAM TO THE WORKS. HOT WATER FROM THE STILLS IS TREATED IN A CENTRAL WATER TREATMENT PLANT

STEAM PLAYS such an important part in the processes of oil refinery work that its economic production and distribution is an engineering problem of no little importance. Moreover, an oil refinery is not a compact type of industrial development; it usually spreads over a considerable ground area not only because of the nature of the processes but partly to reduce the destructive effects of possible fires. The last factor mentioned—fire hazard also has had an important bearing on the use of electricity in these plants.

FACTORS AFFECTING PLANT DESIGN

Naturally the methods used in steam production have been influenced by the particular conditions. Boiler plants were built as near as possible to the points where the steam was to be used and, as the refinery grew, other boiler plants were added to take care of the demands. Extensive pipe line distribution of steam was considered to be neither feasible nor practical. Motor drive for pumping and other uses was looked upon as adding another hazard without equal compensation in the way of increased process efficiency.

Passing years, with the growth of new engineering methods, the development of improved equipment and the necessity for reducing labor costs, have materially altered the solution of power problems in oil refineries. Centralized steam production and the electric drive have both become accepted practice.

An excellent example of this trend of development is shown in the plant of the Vacuum Oil Co. at the Olean, N. Y., Works. Here three old boiler plants have been supplanted by a modern boiler plant rated at 5341 b.hp. which has just gone into complete operation. Some 10,000 ft. of high pressure and exhaust steam distributing lines, erected in line with the best practice, have been constructed. Underground cable distribution of electrical energy and the use of oil switches with all motor applications has been the method of approach in solving the fire hazard problem.

This development at Olean is of particular interest since the plant is a good example of modern design with a number of special features which take it out of the standardized class. By referring to the sectional view of Fig. 1, an idea may be had as to the general arrangement of the plant.

Continuity of service has been the keynote of the entire design and an idea of the care with which this has been worked out may be gleaned from the fact that the coal handling system has been installed in duplicate. Two standard gage tracks with separate track hoppers and crushers are located at the boiler room side of the station as will be noted from Fig. 1. The crushers are double roll type and are driven by 20-hp. squirrel cage motors. The crusher under the outside track has an apron feeder and the other is equipped with a reciprocating feeder.

As a protection to the operator and also to keep snow out of the hoppers, a concrete canopy has been built over the unloading hoppers, as shown in Fig. 1A. The ash bunker is not over this canopy, however, as might seem to be the case from an inspection of the sectional view but is at the end of the station. Reference to the plan view in Fig. 3 will make this clear.

After leaving the crushers, the coal is carried by bucket elevators up to a flight conveyor which runs lengthwise of the coal bunker. This flight conveyor is not installed in duplicate since its only purpose is to distribute the coal throughout the length of the bunker. If it should go out of commission it would not cause a plant shut down. A view of this flight conveyor is shown in Fig. 1 B. Distribution is obtained by opening slides in the trough to allow the coal to fall through at the desired points. Approximately 1000 T. is the capacity of the steel bunker.

From the bunker the coal feeds down through spouts to the belt feed coal scales. Each stoker is equipped with one of these scales which are of the automatic type with a 200-lb. capacity per dump.

Three spouts from the bunker are provided for every two stokers. That is, stokers on opposite sides of the firing aisle can be fed from all or any one of the three spouts. The advantage in the arrangement lies in the fact that coal is drawn out of the bunker at more points, inactive pockets of coal are less likely to form and a greater volume of coal can be handled in a limited time than would be the case if only one spout were provided.

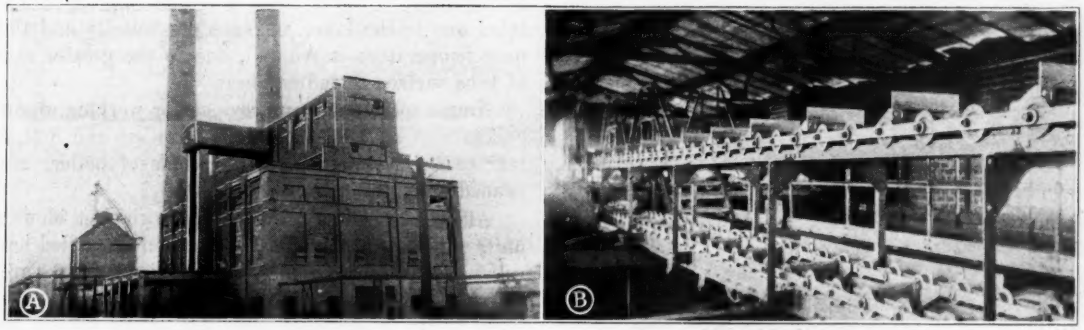
Now that the flow of coal has been followed up to its entrance to the boiler furnaces, the next points of interest concern the boilers and the stokers. The boiler installation is made up of seven 763 hp. units. These are cross drum boilers 14 tubes high and 27 tubes wide and designed for an operating pressure of 200 lb. and 100 F. deg. superheat. From Fig. 3 it will be noted that four of the boilers are placed on one side of the aisle and three on the other side with space arranged for an additional boiler.

DUAL DRIVE FOR STOKERS

Each boiler is fired by a seven-retort underfeed stoker. One interesting feature of the stoker installation is the provision which has been made for dual drive. Each stoker is driven by a 5-hp. W. slip ring motor through a 4-speed and reverse truck transmission. In addition the four stokers on one side and three stokers on the other may be driven by 6 by 7-in., 175-r.p.m. engines. Figure 1 C shows the arrangement of these two engines. Sectionalizing clutches are left open when the stokers are running on motor drive.

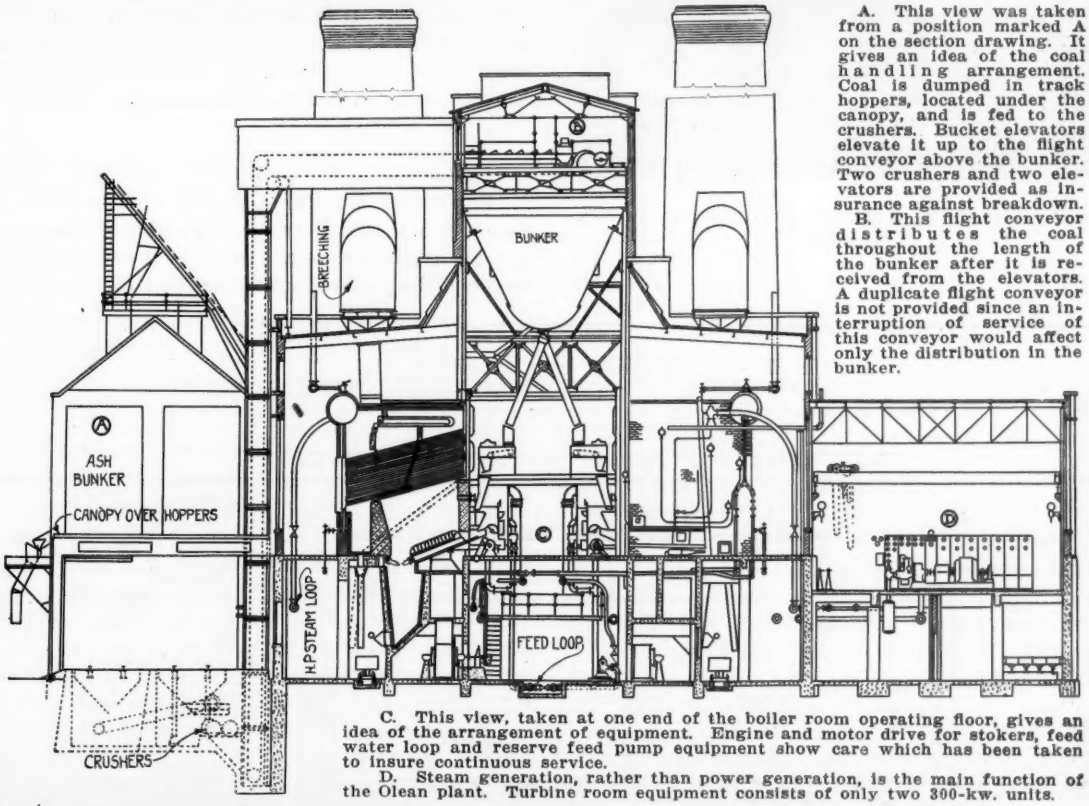
From the sectional view in Fig. 1, an idea can be obtained as to the arrangement of the boiler installation. It will be noted that the bridge wall is set well back; ashes feed down into a narrow hopper for discharge into industrial cars; the first baffle is inclined so that the gas passage through the first two passes is constricted; and the flow of flue gas is straight up from the third pass to the breeching.

Fig. 1. Service Reliability Has Been the Keynote in the Design



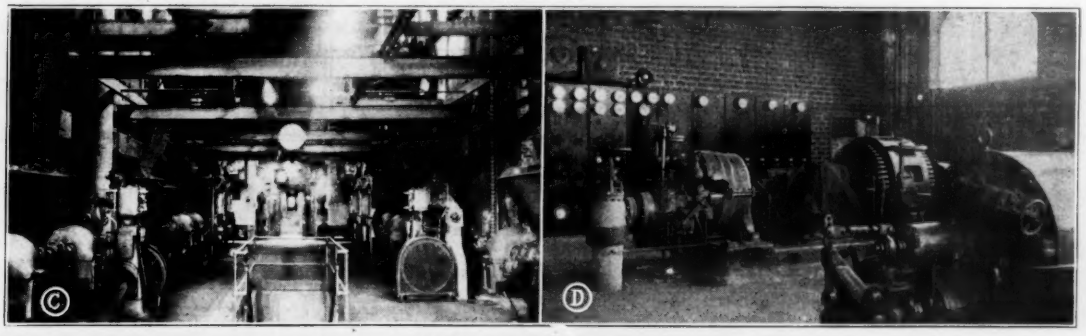
A. This view was taken from a position marked A on the section drawing. It gives an idea of the coal handling arrangement. Coal is dumped in track hoppers, located under the canopy, and is fed to the crushers. Bucket elevators elevate it up to the flight conveyor above the bunker. Two crushers and two elevators are provided as insurance against breakdown.

B. This flight conveyor distributes the coal throughout the length of the bunker after it is received from the elevators. A duplicate flight conveyor is not provided since an interruption of service of this conveyor would affect only the distribution in the bunker.



C. This view, taken at one end of the boiler room operating floor, gives an idea of the arrangement of equipment. Engine and motor drive for stokers, feed water loop and reserve feed pump equipment show care which has been taken to insure continuous service.

D. Steam generation, rather than power generation, is the main function of the Olean plant. Turbine room equipment consists of only two 300-kw. units.



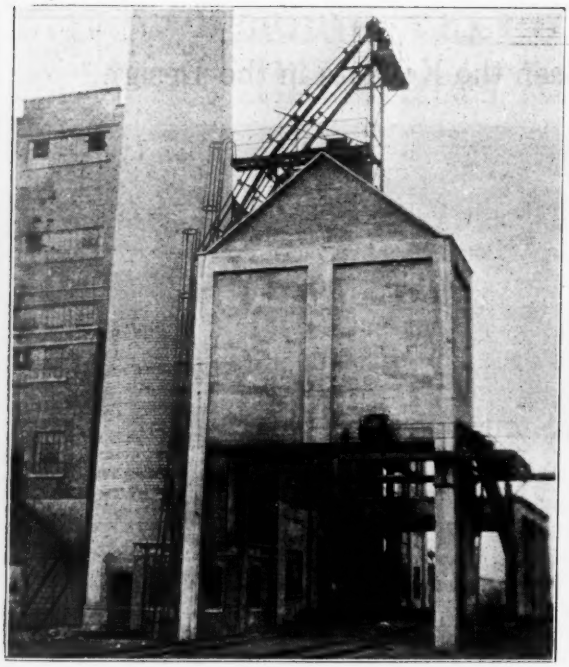


FIG. 2. SKIP HOIST IS USED TO CONVEY ASHES TO THE BUNKER

In order to reduce the possibility of clinker troubles, the furnaces are lined with carborundum brick up to the clinker line. Five of the boilers are equipped with 35 deg. baffling and two boilers have monolithic baffles. This arrangement of baffles tends to reduce slag deposits on the tubes due to the lower entrance gas velocity and the furnace temperature is reduced, due to the greater exposure of tube surface to radiant heat.

Ample space has been provided for working around the boilers with an 8 ft. aisle between boilers and 8 ft. at the rear of the boilers. The front ends of boilers are suspended from the main building steel.

All of the boilers are equipped with soot blowers, six units per boiler and the last four boilers installed have the valve-in-head type. Straight-type water columns are used and each boiler is equipped with a feed water regulator. Each boiler is equipped with five safety valves, four of which are on the drum and one on the superheater. These valves are piped to a common header for each boiler as shown in Fig. 6. Three blowoff valves for each boiler are piped to a common blowoff line and tank for each row of boilers. A sectional view of this piping is shown in Fig. 6 and the plan view in Fig. 4.

Air Supply Drawn from Top of Boiler House

One rather interesting feature of this boiler house design is in the arrangement which has been made to supply the combustion air. In many plants air is either drawn directly from outside the building or else drawn

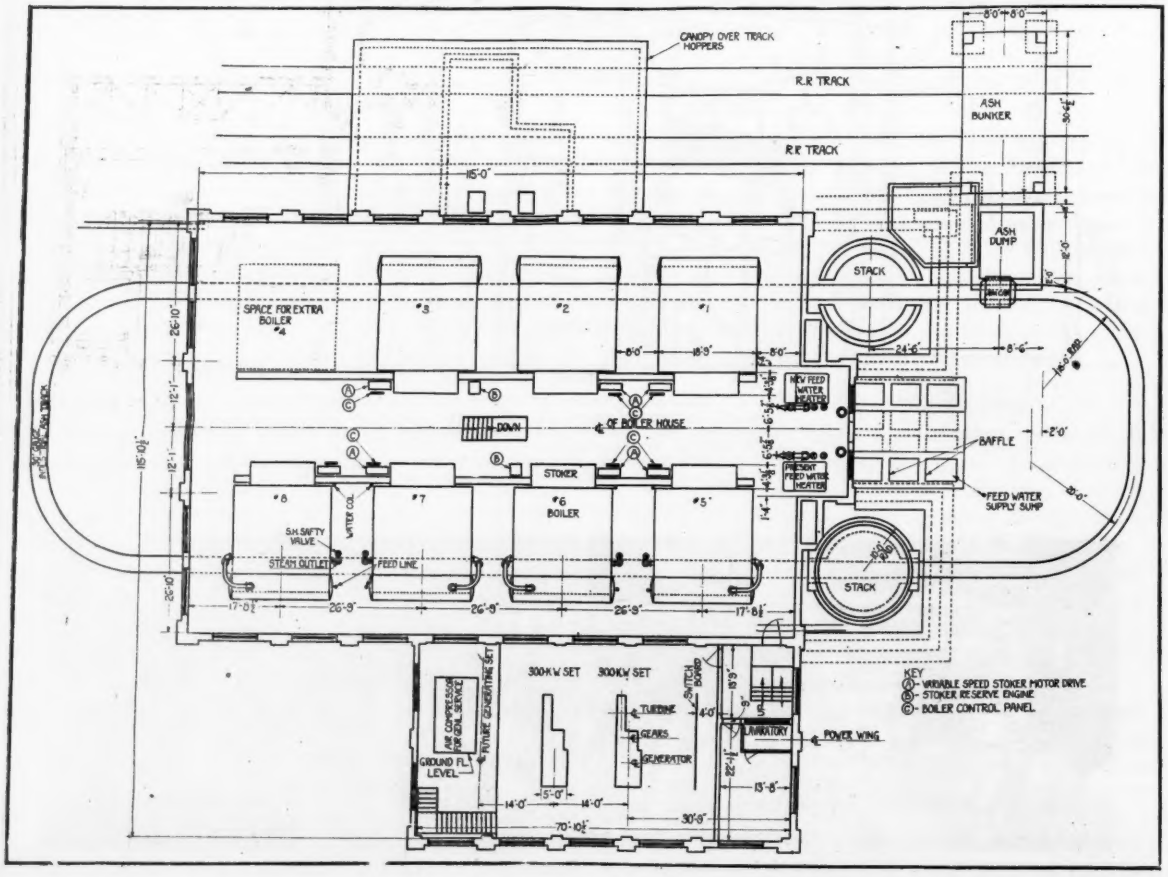


FIG. 3. PLAN VIEW GIVES AN IDEA OF THE CONTROL STATION AND STOKER DRIVE ARRANGEMENT

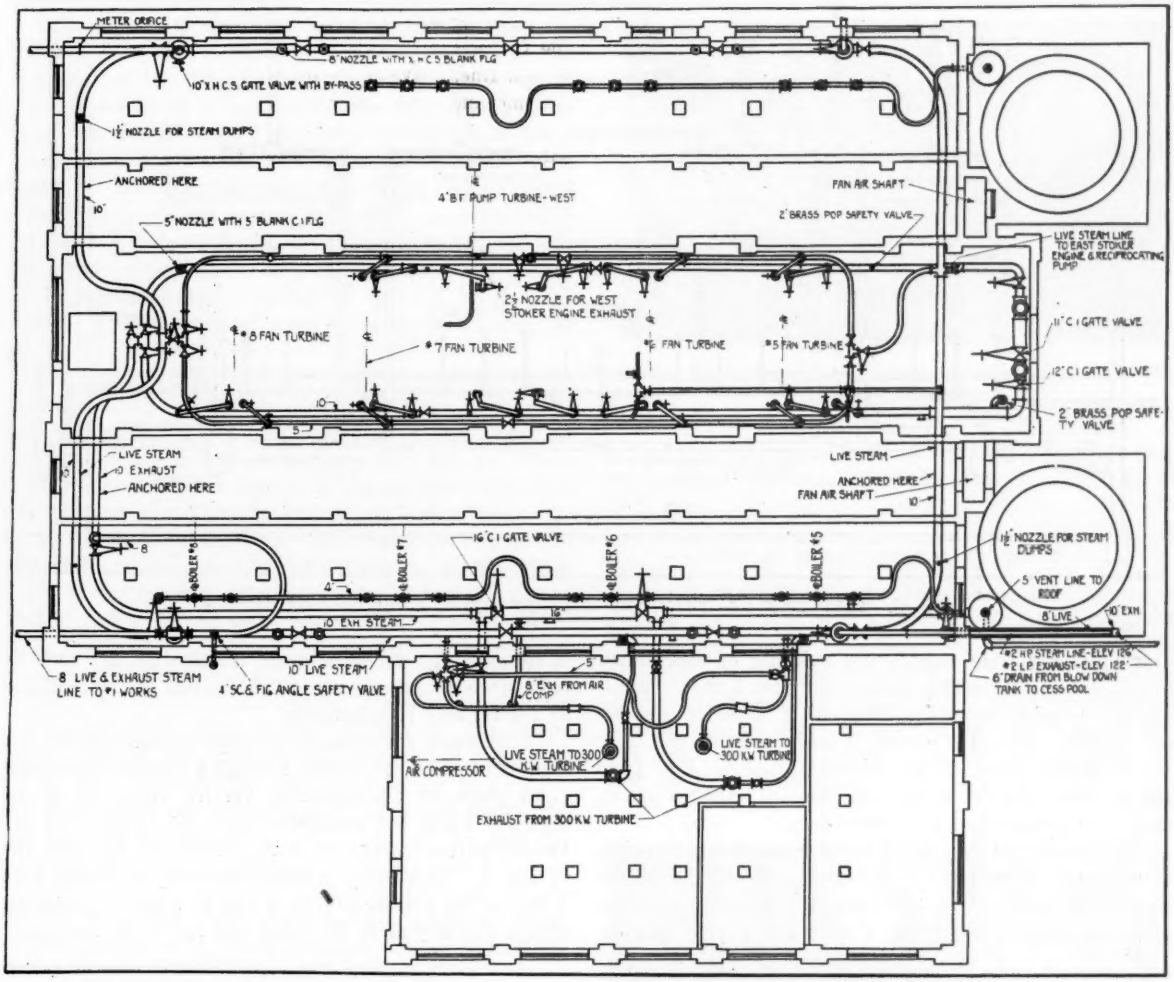

METER ORIFICE
8" NOZZLE WITH ¼" C.S. BLANK FLG
10" X H.C.S. GATE VALVE WITH BY-PASS
1½" NOZZLE FOR STEAM DUMPS
ANCHORED HERE
4' B.F. PUMP TURBINE - WEST
FAN AIR SHAFT
2" BRASS POP SAFETY VALVE
5" NOZZLE WITH 5" BLANK C.I. FLG
LIVE STEAM LINE TO EAST STOKER ENGINE & RECIPROCATING PUMP
2½" NOZZLE FOR WEST STOKER ENGINE EXHAUST
#8 FAN TURBINE
#7 FAN TURBINE
#6 FAN TURBINE
#5 FAN TURBINE
11" C.I. GATE VALVE
12" C.I. GATE VALVE
2" BRASS POP SAFETY VALVE
LIVE STEAM
10" EXHAUST
ANCHORED HERE
LIVE STEAM
ANCHORED HERE
FAN AIR SHAFT
16" C.I. GATE VALVE
BOILER #8
BOILER #7
BOILER #6
BOILER #5
1½" NOZZLE FOR STEAM DUMPS
5" VENT LINE TO ROOF
8" LIVE
10" EXH
10" EXH. STEAM
16"
#2 HP STEAM LINE - ELEV 126'
#2 LP EXHAUST - ELEV 122'
6" DRAIN FROM BLOW DOWN TANK TO CESS POOL
8" LIVE & EXHAUST STEAM LINE TO #1 WORKS
4" SC & FIG ANGLE SAFETY VALVE
10" LIVE STEAM
8" EXH FROM AIR COMP
LIVE STEAM TO 300 K.W. TURBINE
AIR COMPRESSOR
LIVE STEAM TO 300 KW TURBINE
EXHAUST FROM 300 KW TURBINE

FIG. 4. STEAM PIPING IS ARRANGED IN A LOOP WHICH ENCIRCLES THE BOILER ROOM

directly into the fans from the boiler room with no provision for definite circulation. In the latter case drafts are sometimes created which make the boiler room a rather disagreeable place to work in during the winter months.

In the Olean boiler house, however, the fans are supplied by air through two vertical shafts which lead up to the top of the boiler house. The fans are located in a separate gallery on each side of the center bay and each boiler has its own fan of 27,500 cu. ft. per min. capacity at 6.75 in. pressure, driven by a turbine. Windows have been placed at the end of the galleries so that air may be drawn in directly from outside if desired.

Each fan gallery has its own air duct with sectionalizing air dampers between each boiler. Ordinarily the fans are run independently so that the draft regulation may be made to conform to the particular combustion conditions. Each fan will, however, handle two boilers at 175 per cent rating or one fan can be used to handle the entire group for lower ratings. The two main air ducts are not interconnected.

Ash Handling by Industrial Cars

Another place where considerable ingenuity has been exercised is in the layout of the ash handling system. The arrangement is simple and yet it has been found to be quite effective as well as economical. The main feature of the system is a track for industrial cars which has been laid out in elliptical form so that it passes under each row of boilers and through the base of the two stacks. In each stack is suspended a steel soot hopper, which is emptied at intervals directly into the ash cars.

From the ash hoppers the ashes are dumped into the cars through hand-operated side discharge ash gates which were built on the job. The 1-yd. cars are picked up by a locomotive as shown in Fig. 5 and hauled to the dump at

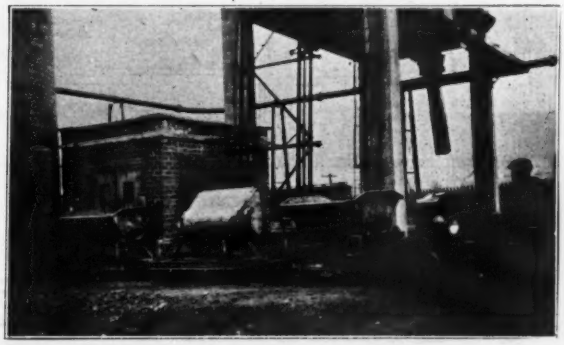


FIG. 5. ASH CARS ARE MOVED BY A GASOLINE LOCOMOTIVE

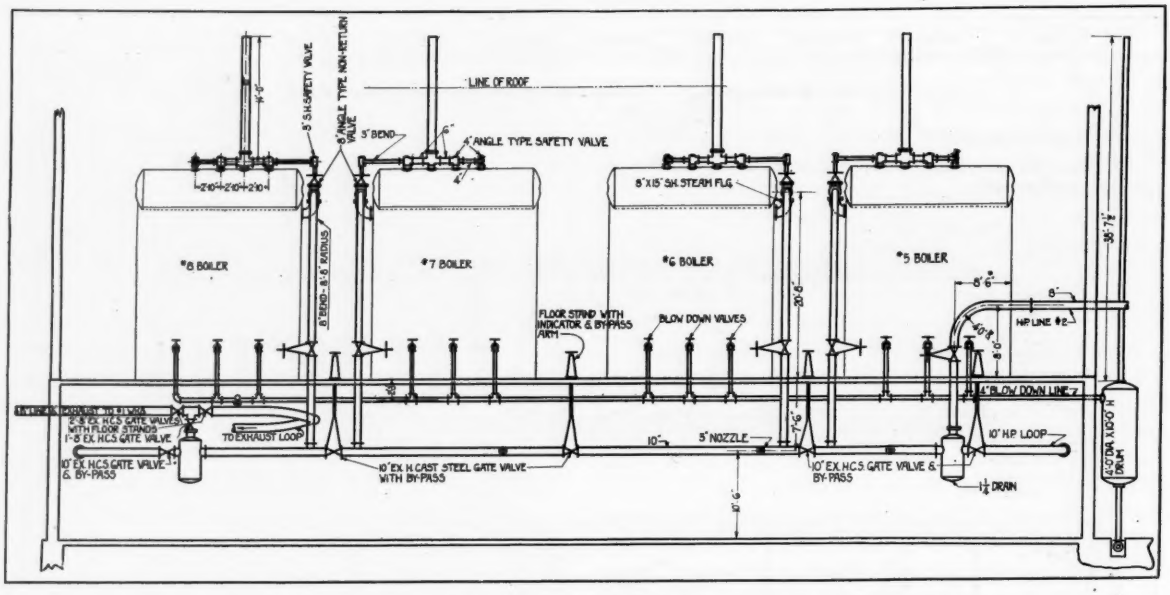


FIG. 6. ELEVATION OF STEAM AND BLOWOFF PIPING FROM REAR OF BOILERS

drawn directly from outside the building or else drawn the skip hoist. This skip hoist, with push button control, carries the ashes-up to the 7500 cu. ft. capacity concrete ash bunker. From the bunker the ash is discharged from a side spout, shown in the sectional view of Fig. 1, to trucks which distribute the ash for fill. Center spouts under the bunker feed to railroad cars.

With a general idea of the boiler house design in mind, it will now be possible to consider some of the details which have had to be worked out in connection with the special conditions involved. Feed water supply and exhaust and high pressure steam distribution are such details, since the arrangement of the system has been affected by the refinery requirements.

Feed water for instance is received from the oil condensers after having passed through a central water treatment plant, at a temperature varying from 100 to 150 deg. F. From the treatment plant the water flows to a two-compartment concrete sump, shown on the plan view of Fig. 3. This sump is baffled vertically to within about a foot of the bottom so that it acts as a settling tank and also so that any oil in the water will rise to the surface.

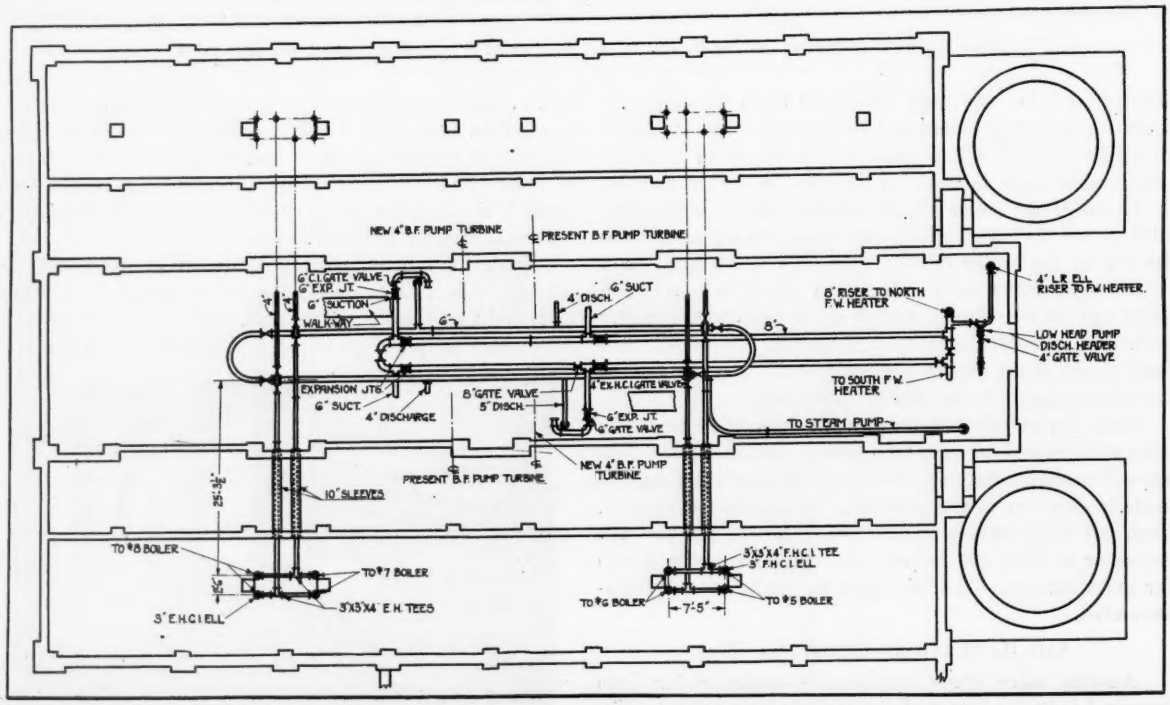


FIG. 7. FEED PIPING LOOP IS LOCATED IN A TRENCH AT THE GROUND FLOOR LEVEL

Just inside of the building, at a level slightly below the basement floor, is the pump pit. The equipment in this pit consists of two low-lift single stage 4-in. pumps, one of which is driven by a turbine and the other by a motor. These two pumps supply the two 5000-hp. feed water heaters. As an emergency measure a duplex steam pump, located in this pit, will supply water to either heater or to the boilers direct as may be desired. A motor-driven house service pump supplies water for ash quenching, turbine gland sealing water and other such service by pumping to the house tanks located at the end of the coal bunker. A float controlled sump pump keeps the pump pit dry.

From the pump pit the feed water is delivered to the Cochrane heaters located on the boiler room floor. The suction lines and feed lines from these heaters and from the pumps to the boilers are laid as a loop system. These loops are located in a trench at the ground floor level. The feed pumps are also located at this level.

As the work on the boiler room has been handled in two separate steps it will be noted from the piping layout of Fig. 7 that the first installation consisted of two pumps rated at 220 g.p.m. at 2800 r.p.m. Each of these pumps would take care of the feed requirements of the original installation of three boilers.

With the complete installation of seven boilers, two more pumps have been added. These are three-stage pumps rated at 450 g.p.m. at 2800 r.p.m. and a head of 525 ft. and are driven by turbines. Either side of the loop with one of the new pumps running will supply the feed requirements of the seven boilers, or the two old pumps together will supply the entire requirements.

As an interjection at this point, it is of interest to note that the frame sizes of the fan turbines and the feed pump turbines are the same so that a certain degree of mechanical interchangeability is possible.

Pump governors are used to control the feed pressure. Both sides of the feed water loop are carried to each boiler although only one side goes through the feed water regulators. The boilers normally are fed from that connection. The main feed loop is of wrought iron pipe and the branch lines to the boilers are brass.

Since it was necessary to make provision for tapping the main steam header at several points to distribute steam around the works, the header has been laid out to encircle the boiler room below the boiler room floor. This arrangement is shown in Fig. 4. It will be noted that distributing lines tap off at the four corners of the plant.

In addition an auxiliary steam header, located above the boilers, takes steam from three boilers for supplying the auxiliaries. From this auxiliary header a separate steam loop supplies steam to the fan turbines. This is done so that the steam pressure to the fan turbines can be regulated. A separate steam loop is also provided for the feed pump turbines. Both of these loops may also be fed from the main steam loop at either end of the house.

High pressure steam lines are insulated with 3 in. of 85 per cent magnesia. The distributing lines are supported on steel towers and distribute at 175 lb. pressure and 100 deg. F. superheat. The high pressure lines consist of 5000 ft. of 8-in. with 1600 ft. of 5 and 6-in. branches. In addition there is 1200 ft. of 8-in. line for emergency use and the piping connections are arranged so that this line may handle either high pressure or exhaust steam. The regular exhaust lines total 1700 ft. of 10-in. pipe.

FIG. 8. COAL FEEDS DOWN FROM THE BUNKER THROUGH SWINGING SPOUTS

Boiler Room Control Features

Due to the fact that the steam demand is reasonably uniform it was considered unnecessary to equip all boilers with automatic regulation. The three boilers on the north side of the plan carry the swing of the load and have been equipped with mechanical regulation. The four boilers on the south side are operated as a unit by controlling the fan loop steam pressure through a balanced valve operated from the boiler room floor.

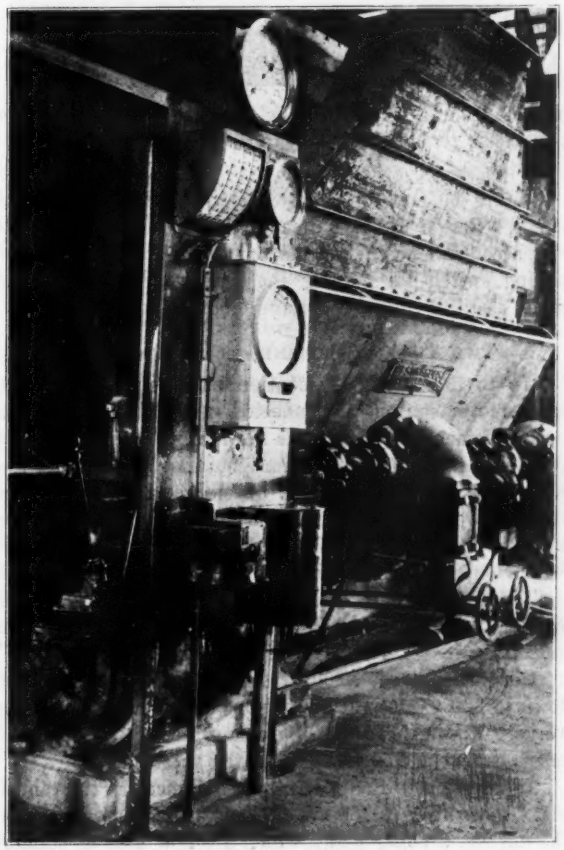


FIG. 9. EACH BOILER HAS ITS CONTROL PANEL

Each boiler has its control panel but since the boilers are arranged right hand and left hand the control stations for each two boilers are adjacent. In reality therefore there are only two points of control, with two panels on each side of the aisle, at each control point.

It is possible to operate the up-take damper for each boiler at its panel by a lever arrangement. These levers are disconnected on the three boilers using mechanical regulation but they may be reconnected if repairs should be required on the regulating equipment.

Each control panel is equipped with a boiler meter reading steam flow, air flow and up-take temperature. A multi-pointer gage reads air pressure in the wind box, at the front dump plate, at the rear dump plate and the furnace draft. Additional instruments on the boards are gages reading boiler steam pressure, feed water loop pressure and fan loop steam pressure. A master steam gage located at the center of the firing aisle shows the main header steam pressure and a recorder keeps a graphic record of this pressure.

FIG. 10. SOME 10,000 FT. OF STEAM LINES DISTRIBUTE STEAM AROUND THE WORKS

Figure 9 shows a view of one of the boiler control panels. Beside the instruments the panels are equipped with a controller for the stoker motor and a small disconnecting switch for cutting the primary current off the motor as these are wound rotor motors.

Two 300-Kw. Turbines in Power Wing

Up to this point no mention has been made of the prime mover equipment connected with this plant. As a matter of fact, this part of the installation is overshadowed by the boiler room as the steam requirements are more important than the generation of electrical energy. The plant, however, has a small turbine room in which are located two 300-kw. turbine units. A two-stage air compressor supplies air for general service at 110 lb.

The central plant also has a switchboard and double bus bar system at one end of the generator room. A substation for local service is located on the ground floor.

Generation is at 2200 v. and the current is stepped down to 220 v. at eight substations distributed around the works. No overhead distribution is used as underground cables carry the current to all of the substations.

In addition to the generating equipment at the central plant there are two 150-kw. geared turbo-generator sets at the old No. 2 boiler plant, which are now used as standby only. These units are operated on steam from one of the distributing lines.

There are also six engines ranging from 50 to 150 hp. which operate on line shaft drives in the pump houses. Two of these are counter-flow automatic, balanced valve engines; two are automatics; one is a Corliss and one was originally a Corliss ammonia compressor but was changed over for steam operation. These engines are also operated with steam from the distributing lines.

Ordinarily one 300-kw. machine will handle the motor load as the total connected load amounts to 700 hp. The power is used for driving pumps, the machine, carpenter, pipe and boiler shops and for lighting.

Operating Results

With all of these changes which have been made at the Olean Works, it is interesting to note what results have been secured. Probably one of the most important results has been in the reduction of operating force required. The three old boiler plants required 30 firemen, 14 ash wheelers, and the coal was unloaded by the regular yard gang.

As compared with this the new plant requires 9 boiler room operating men consisting of a foreman, water tender and helper on each shift. Three men handle the coal and 4 men handle the ashes. One clean-up man on day shift and 3 engineers, one on each shift take care of the power wing.

Under the old conditions it required about 4.5 lb. of coal per b.hp. as compared with 3.3 lb. per b.hp. now although it is expected that this will be further improved upon. The monthly average efficiency of the boiler plant for the past few months has been 75.2 per cent.

In conclusion we wish to express appreciation to the officials of the Vacuum Oil Co. for courtesies extended during the preparation of this article and to E. H. Wright, Works Manager, and E. H. Atwood, Plant Engineer for the data supplied during the inspection trip.

Priming of Circulating Pumps

Studies made by the Prime Movers Committee of the N. E. L. A. indicate that various priming methods for circulating pumps are in vogue. Independent single-stage steam ejectors provided on each unit seem to be the most popular, although some novel arrangements employing other means were in use in certain plants.

Some of the plants in which R.D.V. pumps were used made use of the air pump for priming the circulating pump and water box, protecting the air pump from water damage by means of a loop or trap in the line.

In one or two plants the priming line extends the length of the pump room, and may be connected to any piece of apparatus to be primed. This scheme probably has the advantage over those employing steam jet priming ejectors on each unit, owing to its simplicity.

It is seldom, if ever, necessary to prime all pumps and water boxes in any plant simultaneously, consequently it seems difficult to justify the duplication of piping and equipment necessitated by individual jets for each pump and water box.

In some plants the hydraulic air pump is employed for priming the circulating pump and water box. This is only possible with the type of hydraulic pump having a large capacity at low vacuum, and reports from member companies indicate that priming by this type of pump is more satisfactory than the use of the priming ejector, owing to the simplicity of the operation involved and to the greater capacity and higher vacuum obtainable.

Jet Condenser Performance

A Detailed Discussion of the Various Factors Affecting the Operation of Jet Condensers. By George E. Gaster

IN THE DESIGN, construction and operation of jet condensers, three things are of prime importance; the first is to introduce the cooling water so as effectively to condense the steam, the second is to get the cooling water and condensed steam out of the condenser and the third is to remove the air and non-condensible vapors that have leaked into the condenser or were carried in with the circulating water or steam.

Jet condensers are built in a variety of forms. By one classification, there are the low level jet condensers, the barometric or high level, the siphon and the ejector condensers. Another classification divides jet condensers into two groups, the parallel-flow and the counter-flow condensers.

In the simplest and one of the earliest forms of the jet condenser, the cooling water falls over ledges to form a spray and the steam is caused to mingle with this spray and become condensed. This type of condenser is still often used in paper mills and other plants where steam is used for cooking and process work.

In an improved form of jet condenser, the steam enters at the top of the head and the condensing water is sprayed in through nozzles, immediately below the steam inlet. Condensing water, condensate and air fall to the bottom of the condenser where they are all removed by one pump. With the advent of the modern steam turbine, with its ability to utilize a very high vacuum, it has become necessary to separate the air and water pumps, so that the modern high vacuum jet condenser has a centrifugal pump to remove the injection water and condensate and a separate air pump to remove the air and other non-condensible vapors.

The barometric or high level jet condenser has its condensing chamber located 34 or more feet above the hotwell to which it is connected by a long pipe sealed with water at the bottom. The external atmospheric pressure maintains a column of water in the tube, in the same manner as mercury is maintained in a barometer. It may be operated with or without an air pump. No water removal pump is necessary. The construction of this condenser is simple and rugged and its operating and maintenance costs are low. Its long exhaust pipe is objectionable and it often adds considerable to the back pressure on the prime mover.

Siphon condensers are in reality barometric condensers. A true siphon condenser, however, is always a parallel-flow condenser, while a barometric condenser may operate on either the parallel-flow or the counter-flow principle. In a siphon condenser, the injection water, condensate and air are all discharged through a contracted throat or nozzle. An air pump is never used with a siphon condenser.

Ejector condensers operate in a manner similar to an air ejector. The exhaust steam enters the condenser through a series of orifices or nozzles and is condensed by the cooling water, resulting in the water and condensed steam being given a velocity high enough to discharge them against atmospheric pressure. This type is not suitable for intermittent service or for loads which vary widely and they are used only in small installations.

In the counter-flow condenser, the steam enters the lower part of the condenser and passes up through the descending, condensing water. The air is removed by an air pump at the top.

In a parallel-flow condenser, the steam and injection water both enter at the top, and the steam, water and air, all flow in a downward direction, where the water, condensed steam and air are removed.

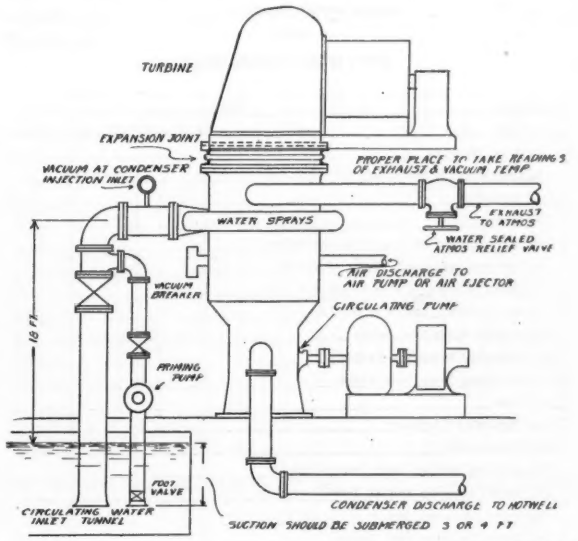


FIG. 1. ARRANGEMENT OF JET CONDENSER AND ESSENTIAL AUXILIARIES

Jet and barometric condensers may be built to operate on either the parallel-flow or counter-flow principle. Siphon condensers and ejector condensers must, from the nature of their operation, operate on the parallel-flow principle.

Figure 1 shows a desirable arrangement for a modern, high vacuum, jet condenser. Provisions should always be made for expansion due to temperature changes in a jet condenser installation. This is usually taken care of by means of flexible expansion joints.

Spray nozzles and condenser head should be so designed that the water and exhaust steam are thoroughly intermixed, and as great a surface of water as possible should be subjected to direct contact with the exhaust steam. The design of the condenser should permit easy access to the inlet water chamber, so that any debris that might lodge there can be easily removed. The ability of a jet condenser to handle dirty circulating water often decides its use in preference to a surface condenser.

If centrifugal water and air pumps are used, it is desirable to place them both on one shaft and drive them both by one prime mover. Bronze pump runners withstand the erosive action of the water better than cast iron.

Due to low steam pressure in a turbine drive, or to electrical trouble in a motor drive, the pump may slow down or too much injection water may be admitted, thus

exceeding the removal pump capacity; in either case, the water level in the condenser would rise to a point where there would be danger of flooding the turbine and perhaps damaging it.

This condition should be guarded against by installing a vacuum breaker, so that when the water level in the condenser reaches a certain height, the vacuum breaker will operate and break the vacuum, thus preventing admission of any more injection water. The vacuum breaker should be water sealed to prevent air leakage during normal operation.

In installations with a lift on the injection line of only a few feet or with a long injection line, where the injection water would continue to flow for some time after the vacuum was broken, due to the velocity head, it is necessary to have an automatic shut-off valve in the injection line. When an automatic shut-off valve is used, there must be a relief valve in the injection line just before the automatic shut-off valve to prevent water hammer.

PUBLIC SERVICE CO. OF_____

_____PLANT.

REPORT OF JET CONDENSER TEST.

Unit No. Date

1. Time	8.00 A.M.	8.10 A.M.	8.20A.M.
2. Steam Pressure			
3. Load on Prime Mover, kw.			
4. Barometer			
5. Vacuum			
6. Vacuum Corrected to a 30-in. Barometer			
7. Absolute Pressure, Inches of Mercury			
8. Vapor Tension, Inches of Mercury			
9. Air Tension, Inches of Mercury			
10. Exhaust Steam Temperature			
11. Discharge Water Temperature			
12. Injection Water Temperature			
13. Rise			
14. Terminal Difference			
15. Submergence			
16. Air Pump Suction Water Temperature			
17. Vacuum Air Pump Suction Inlet			
18. Steam Condensed, Pounds			
19. Injection Water Used, Pounds			
20. Ratio Lb. of Water per Lb. of Steam			

FIG. 2. FORM USED FOR REPORTING JET CONDENSER TESTS

A water sealed atmospheric relief valve is necessary to permit the steam to exhaust automatically to the atmosphere in case the vacuum is lost, and to permit of starting up or running the turbine noncondensing. The water seal prevents air leakage that might impair the vacuum in the condenser.

Location

Proper location of a jet condenser depends on the water levels and the location of the engine or turbine. Theoretically a 28-in. vacuum can lift a column of water over 31 ft. But there is pipe friction to overcome, a pressure drop through the spray nozzles, and a margin of safety must be allowed in order to guard against losing the vacuum with a sudden increase in load.

Ordinarily the measured lift should be limited to about 18 ft., depending on the amount of pipe friction. Therefore it is desirable that we stay within certain suction and discharge limits. By placing the condenser directly beneath the turbine or engine, we have the advantage of saving floor space and less expensive exhaust connections, but the added disadvantage of inaccessibility.

Occasionally a jet condenser is located on the same level with the prime mover but such an arrangement should be avoided if possible, as it usually necessitates a large number of bends and joints and increases the possibility of air leakage. If the exhaust pipe does not drain directly into the condenser, the lowest point in the pipe should be provided with a drip, which should be opened when the unit is shut down. Under no circumstances should the end of this drip extend into a volume of water, for if the unit should be put into operation under those conditions without closing the drip valve, water will be drawn into the exhaust line.

It is usually desirable to locate a barometric condenser outside of the engine room. The exhaust pipe should, however, be as short and free from bends as possible, in order to reduce back pressure on the prime mover.

Use of Valves Between Condenser and Prime Mover

Small jet condensers usually have an exhaust gate valve between the condenser and the prime mover. In putting the unit into service, the exhaust gate valve is closed and the air pump is utilized to exhaust the air from the condenser, creating sufficient vacuum to draw the injection water into the condenser. In the meantime the circulating pump has been started. The gate valve in the injection line is set so that the proper submergence will be obtained. The exhaust gate valve can now be opened, admitting steam to the condenser.

In large condensers, it is not feasible to use a gate valve between the prime mover and the condenser, so that a priming pump must be used to force the water through the spray nozzles in order to condense the steam and establish a vacuum, after which the priming pump may be shut down and the injection water will be drawn into the condenser by the vacuum.

Keeping Performance Records

In the successful operation of a jet condenser, a continuous record should be kept of its performance, the completeness and scope of this record to depend on the size and layout of the installation.

In large jet condenser installations, the writer has found it desirable to have the watch engineers take the following readings at regular intervals:

Load on prime mover
Barometer
Vacuum
Steam temperature at condenser inlet
Discharge water temperature
Injection water temperature
Submergence
Air pump suction water temperature.

In Fig. 2 is a form which has been found convenient in reporting jet condenser tests.

Care should be exercised to eliminate all errors due to incorrect temperature readings, air leaks in mercury column or in line to mercury column, water in mercury column or water pockets in line to mercury column and improper setting of the mercury column.

Readings of the load, vacuum, exhaust temperature, and discharge water temperature must all be taken at the

same instant, as these factors all change with a change in load.

Total steam entering condenser may be ascertained in varying degrees of accuracy by steam flow-meters, or if the blades and nozzle of a steam turbine are not too badly worn, the guarantee steam consumption curves of the turbine builder may be used.

Barometer readings should be taken with a mercurial barometer. The level of the mercury in the well must be at zero when a reading is taken. When reading a barometer or a mercury column, always read on a line with the top of the meniscus or top surface.

Vacuum at condenser steam inlet should be read on a mercury column. An ordinary spring vacuum gage is not sufficiently accurate. The connection to the mercury column is preferably made at a point on the pipe leading from the main exhaust to the atmospheric exhaust relief valve. The purpose of this is to eliminate any possible chance of error due to eddies in the steam. The pipe to the mercury column should not be smaller than ⅜-in. and as short and tight as possible. It must be free from pockets or places in which water could become trapped, for the weight of even a small amount of water in this pipe will cause an incorrect reading.

If the exhaust pipe is longer than 10 ft., or has more than one bend, the vacuum at the turbine exhaust outlet and also at the entrance to the condenser should be taken.

Exhaust steam temperature is best obtained in a well located in the top of the atmospheric exhaust pipe, between the condenser and the atmospheric relief valve.

Submergence is the height of the level of the water in the condenser body above the center line of the removal pump. In jet condensers served by centrifugal pumps, it is necessary to carry the water in the condenser body up to a certain height, in order to keep the pump runner passages full of water, and to secure full capacity and maximum efficiency.

Air pump suction water temperature is of importance, for in installations using a hurling water pump, if the water is too warm it will evaporate in the pump and obstruct the air flow. It should be no warmer than the main injection water and the colder the better.

Terminal difference is the difference between the temperature of the exhaust steam and the discharge water. It should be from 4 to 8 deg. F. for vacuums from 27.5 to 28.6 in. of mercury, referred to a 30-in. barometer. The higher the vacuum the greater will be the terminal difference, other conditions remaining the same.

High terminal difference may be due to air leaks, air removal pump not working properly, poor distribution of condensing water, excessive vacuum drop through the condenser from throttling and from low discharge temperature.

Rise is the amount the injection water is increased in temperature in passing through the condenser. A large rise is due to a heavy load or to an insufficient supply of water.

Ratio is the number of pounds of cooling or injection water required to condense one pound of steam. It is equal to the pounds of injection water used divided by the pounds of steam condensed.

In Fig. 3 curves are plotted from the results of tests on a low-level jet condenser, equipped with a separate air pump. They show the results obtained by varying the ratio of injection water to steam condensed, also the effect on the vacuum of different injection water temperatures.

Absolute pressure is recorded because the atmospheric pressure is continually changing due to different climatic or altitude conditions. The steam tables must obviously be made out for some base that will always remain the same, therefore the steam tables we use are compiled on the basis of a 30-in. barometer, and it is always necessary to correct our mercury column reading to a 30-in. barometer.

To correct to a 30-in. barometer, if the barometer reading is above 30 in., subtract 30 from the reading and subtract this difference from the mercury column reading; the results will be the vacuum referred to a 30-in. barometer. If the barometer reading is below 30 in., subtract the reading from 30 and add the difference to the mercury column reading to obtain the vacuum referred to a 30-in. barometer.

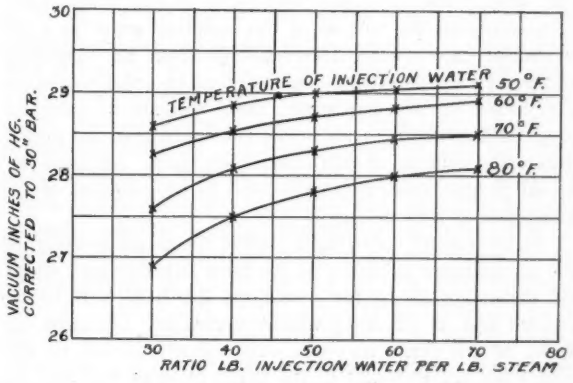


FIG. 3. RESULTS OF TESTS OF LOW-LEVEL JET CONDENSER WITH SEPARATE AIR PUMP

The absolute pressure in a condenser is the total pressure in the condenser. It is composed of the combined air and vapor tensions. In a closed vessel, partly filled with water, a certain, definite, amount of water will be evaporated until the space above the water is filled with water vapor to the point of saturation. This vapor will exert a certain definite pressure depending on the temperature. The air tension is caused by air leaks, and by air being carried into the condenser with the steam and injection water.

The following examples illustrate the method of determining the vacuum referred to a 30-in. barometer, the absolute pressure and the air and vapor tension:

Vacuum 28.2 in. of mercury
Barometer 30.2
Hotwell temperature 94 deg. F.
30.2 — 30.0 = 0.2
28.2 — 0.2 = 28.0 in. vacuum referred to a 30-in. barometer.

The absolute pressure or the combined steam and vapor tension equals 30.0 — 28.0 = 2.0 in. of mercury.

From the steam tables we find that with a hotwell temperature of 94 deg. F. the pressure due to vapor tension is 1.6 in. of mercury.

Since the absolute pressure or the combined air and vapor tension in the condenser is 2.0 in. of mercury, therefore 2.0 — 1.6 = 0.4 in. of mercury is the pressure due to the presence of air in the condenser.

Since the vacuum is 28.0 in., by referring to the steam tables we find the temperature of the exhaust steam to be 101 deg. F. Therefore the terminal difference is 101 — 94 = 7 deg. F.

The amount of injection water used may be determined by the following formula:

$$Q = \frac{W\ H}{R}$$

Where

W = Pounds of steam condensed
H = Units of heat, B.t.u. given up by one pound of steam in condensing
R = Rise in deg. F.
Q = Lb. of injection water used.

In a surface condenser it is usually good practice to vary the amount of circulating water in proportion to the change in temperature of the circulating water. Theoretically this statement is also true for a jet condenser; however, changing the volume of the injection water in a jet condenser has several disadvantages from an operating viewpoint. By throttling the injection in order to reduce the volume of injection water, there will not be sufficient pressure head through the spray nozzles to give the proper water distribution in the condenser head. Also the removal pump discharge would have to be throttled or the pump run at a lower speed.

In the case of centrifugal pumps, the pump is designed for a maximum efficiency at its rated capacity and speed. By throttling the pump discharge, the head will be increased and its efficiency will be decreased. Lowering the speed of the pump may not only mean lowering its efficiency but the efficiency of the pump drive as well and the lower power consumption sought will not be obtained.

Since the only reason we have for using a condenser at all is the effect that it has on the power plant cost and since, with the jet condenser, it is advisable to use a constant amount of cooling water, it is a wise policy to install a jet condenser sufficiently large to give the most economical vacuum during the greater part of the year but not large enough to give the highest vacuum that can be utilized by the prime mover during extremely warm weather, as it is more economical to operate a few days with a low vacuum, hence a higher steam consumption, than to invest more capital in a large condenser, whose excess capacity can be utilized only for a short period of time, but whose extra operating costs, injection water requirements, and depreciation will extend over the whole year.

Air Leakage and Air Removal

Air leakage and air removal play an important part in the successful operation of jet condensers. The presence of air in the condenser increases the total absolute pressure in the condenser, and the rate of air leakage into the condenser, determines the amount of power required for its removal.

If all of the air removed from a condenser is caused to discharge through an orifice, its volume may be calculated by the following formula:

$$Q = 0.57\ d^2 \sqrt{H\ T}$$

Where;

Q = Cu. ft. or air discharged per min.
d = Dia. of orifice in in.
T = Absolute temp. deg. F. of the air discharged
H = Difference in pressure measured by a differential gage in in. of water on the two sides of the orifice.

Every effort should be made to reduce air leakage in a jet condenser. The larger leaks may be detected with the aid of a candle while the condenser is in service or by filling the condenser body with water. If the leakage is larger with a small load than with a large load, in a turbine installation, it indicates that there are leaks in the turbine cylinder.

Sometimes air leakage occurs in the air pump or in the line to the air pump. This can be determined by connecting a vacuum gage to the air pump and running the air pump with the valve between the air pump and condenser closed.

It is good practice to paint the condenser and all connections with an asphaltum paint.

In order to secure efficient air pump operation, it is imperative that the air and vapor going to the air pump be cooled as much as possible. This will result in much of the water vapor becoming condensed and the volume of the air will be reduced according to Charle's Law.

Example: Assuming a hotwell temperature of 95 deg. F., vacuum 28 in., air pressure .345 in., vapor pressure 1.655 in. Cooling the vapor to 62 deg. F., the vapor pressure will be .56 in. Therefore the air pressure is 1.44 in.

$$.345 : 1.44 \text{ as } 1 : X$$
$$\therefore X = 4.2$$

which means that the capacity of the air pump has been increased 4.2 times by cooling the air to the air pump from 95 to 62 deg. F.

Recent Developments in Feed Pump Design

There have been few changes of any great extent in the manufacture of pumps for boiler-feed purposes for the usual pressures. Most of the prominent manufacturers have devoted their efforts to the detailed refinement of existing lines and to the design and production of pumps to meet the constantly increasing demand for higher pressures. This work has consisted mainly in the strengthening of castings to meet the greater stresses and the use of higher speeds to keep the number of stages within reasonable limits. As an example of the extent of the trend toward higher pressures, one company reports that since the beginning of 1922, 23 per cent of its pumps have been built for pressures between 300 and 500 lb. One manufacturer reports the development of pumps with cast steel casings for boiler pressures up to 1300 lb., and with speeds from 3400 to 3600 r.p.m. Very little information is available as yet concerning boiler feed pumps for steam pressures of 1200 lb. or on methods of controlling the boiler feed pressure.

The question of control of motor drives for feed pump does not seem to be satisfactorily settled and the opinion is expressed that considerable development work must yet be done along these lines before the required results are obtained.

The advantage of single suction over double suction pumps, where more than three stages are required is strongly emphasized by another manufacturer.

One concern has succeeded in developing a small compact 3800 r.p.m. single-stage pump, which is capable of feeding 120 g.p.m. at 175 lb. pressure.—N. E. L A. Prime Movers Report, 1924.

Pipe Connections to Power Units

STRAINS RESULTING FROM THE WEIGHT OF PIPE CONNECTIONS AND PIPE EXPANSION OFTEN THROW UNITS OUT OF ALINEMENT

PIPING SHOULD be of ample size for an engine or turbine and at least the size shown on the foundation plan. It is a safe general proposition to say that the best pipe and fittings, irrespective of first cost, will prove the most economical in the end. If the piping is connected to a main steam header, connection should be made on the top of the header, and, if the connection is made direct to a boiler, a valve should be placed close to the boiler.

Separators are desirable to prevent condensation entering the small clearances on engines, particularly if saturated steam is used. Piping should be set up so as to drain automatically. Droplegs should be used and every precaution taken against having water come over from the boiler, into the piping. If a steam separator is used

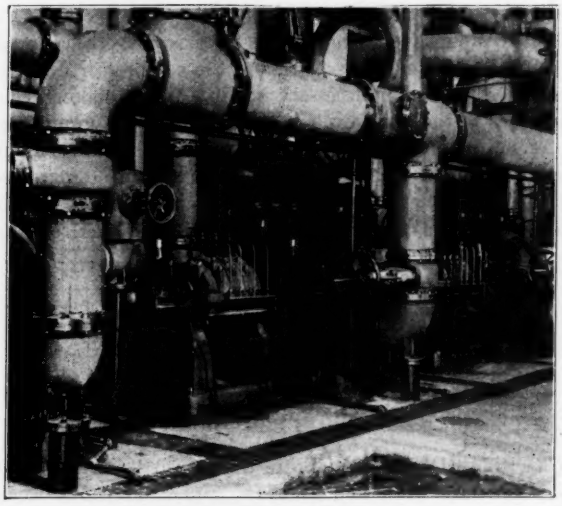


FIG. 1. EXCELLENT EXAMPLE OF PIPING UP PUMPS AND TURBINES

or if the piping to the throttle is heavy, a pipe should be put under the steam yoke to support the weight. The yoke can be held up by a 3-in. pipe, with a screwed flange at the bottom, to allow for vertical adjustment.

Drains from the steam jackets of cylinder heads should be piped to an independent high-pressure, positive-type trap so that all condensate which gathers at these points will be taken away and not enter the cylinder. This trap should be placed in an accessible position near the cylinder, on the engine room floor and the discharge led to the atmosphere, hot well or open feed water heater in such a manner that its discharge is visible and can be checked occasionally.

It would be well, before the steam pipe is put up, to hammer it thoroughly and clean it out, getting out all the chips and dirt possible so that this will not get into the engine or turbine.

Before using the steam piping, it should be thoroughly drained and heated by bypassing steam through the connection provided for this purpose at the throttle valve. The pipes should be thoroughly warmed and dry steam should issue from this bypass connection before opening the throttle valve. The piping should be all blown out thoroughly before using. This can be done by removing the bonnet of the engine throttle, placing a cloth covered board over the opening to the cylinder and then opening the valve near the boiler or header. Before replacing the throttle bonnet and valve disc, carefully clean the valve seat and other parts. If the steam separator is placed above the throttle, it must be drained by a separate trap of positive action.

Exhaust piping should be made the full size indicated on the foundation plan. The piping should be as short and straight as possible to keep down the back pressure. If it is necessary to use a long pipe, or one with a number of bends, the size should be increased. A gate valve should be employed so as to utilize the full area of the pipe. The pipe should be well drained and inclined so as to drain away from the engine. When exhaust drains are run to a hot well, or a heater above the floor, care should be taken that they do not become water sealed, for when starting up and running with extremely light loads, the steam expansion in the cylinder drops below atmospheric pressure, creating a slight vacuum, which, when the exhaust ports are uncovered, may cause the water in the exhaust line to be drawn into the cylinder with disastrous results. Furthermore, if the water in the exhaust line is cold, it may condense the steam striking it, again causing a vacuum which will draw the water back in the exhaust line close to the cylinder. This should be especially watched when starting up a cold engine.

Steam piping bolted to a power unit inlet must be installed in such a manner that absolutely no stress will be placed upon the unit due to the weight of, or the expansion of, the piping. Failure to observe this precaution will not only cause alinement difficulties but may even cause breakage of the unit casing or other parts.

Excessive moisture in the steam is detrimental in that it cuts the governor valve and seats and rapidly erodes turbine blades and nozzle passages. Water entering the turbine in "slugs" invariably cause vibration, broken packing rings and wear and tear in general. Every precaution should therefore be taken to eliminate all water from the steam before it enters the turbine. To this end the steam piping should be carefully arranged and thoroughly drained in accordance with the best power plant practice. In addition to these precautions a separator with proper drains should be installed just ahead of a turbine throttle valve. The installation of a steam strainer in the steam line ahead of a turbine is also highly desirable in order to prevent the entrance into the turbine of foreign matter.

Piping leading to the low pressure inlet of mixed pressure or low pressure turbines must also be carefully drained and prevented from straining the turbine casing. A corrugated copper expansion joint may be used adjacent to the low pressure steam chest as an aid in freeing the turbine casing from expansion strains. A receiver separator of ample capacity should be installed in the low pressure line to free the steam from moisture, oil and foreign matter carried over from the reciprocating engines.

Certain types of low and mixed pressure valve gears require that a flow valve be installed in the low pressure line between the receiver-separator and the turbine throttle valve. This flow valve when properly set will maintain a constant and predetermined back pressure upon the reciprocating engines and upon the low pressure piping system up to the flow valve, regardless of the amount of steam being furnished the turbine and regardless of the load being carried by the turbine.

Expansion Strains May Also Come from Exhaust Piping

As with the high and low pressure inlet connections, the exhaust connection to the turbine, whether the turbine is condensing or non-condensing, must be made in such a way as to relieve the turbine casing of all stresses and strains. With exhaust pipes larger than 6 in. in diameter this is best accomplished by means of an expansion joint of a design which will give the required flexibility and at the same time be suitable for withstanding the vacuum or back pressure being used. For use with a vacuum or with moderate back pressures the corrugated copper expansion joint is to be recommended.

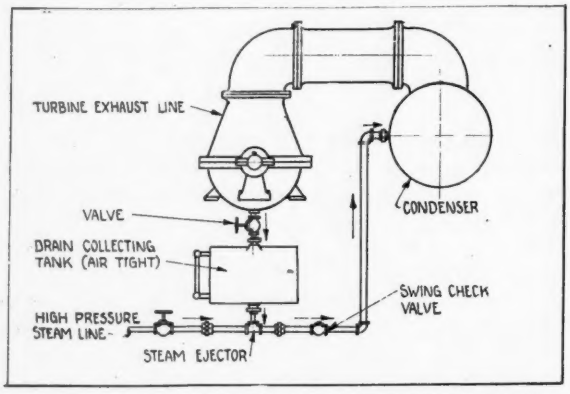


FIG. 2. SCHEME FOR DRAINING TURBINE CASING WITH UPWARD EXHAUST

As a general rule, these expansion joints are flexible only in the direction of the steam flow through them and it is therefore necessary to make sure that the exhaust piping is so arranged that strains lateral to the direction of steam flow through the expansion joint will be either eliminated or taken up. They must also be carefully staged and the exhaust pipe, adjacent to them properly anchored so as to prevent any straining of the turbine casing due to the tendency of the joint to collapse under vacuum or expand under pressure.

In most installations it will be found necessary to install a shut-off valve in the turbine exhaust line. Between this shut-off valve and the turbine there should be installed an atmospheric relief or back pressure valve to protect the turbine casing from excessive pressure in case the turbine throttle is opened when the exhaust shut-off valve is closed.

On condensing units with a downward exhaust and with the condenser directly underneath the turbine no provision for an exhaust end drain is necessary. Condensing units having an upward exhaust, however, need such an exhaust end drain and it is common practice to pipe this either to the hot well pumps on a surface condenser, or to a vacuum trap.

All installations do not make use of a hot well pump and it has been found that vacuum traps at best are not absolutely reliable under all conditions. It is therefore often recommended that the drainage system shown diagrammatically in Fig. 2 be used in connection with condensing turbines having upward exhausts.

As will be seen from the cut the system consists essentially of draining the water by gravity from the exhaust end of the turbine into an air tight tank which is subjected to the same vacuum as the turbine exhaust. The water is removed from the air-tight tank by means of a steam ejector discharging directly into the condenser. A suitable gage glass is provided on the tank so that the water level may be observed at all times. Globe and check valves should be installed and the various connections made as indicated. This drainage system is not automatic in its action unless the steam ejector is allowed to blow constantly in which case too much steam will be wasted. Non-condensing turbines, whatever the direction of their exhausts, should have their exhaust ends drained by means of a trap connected up in the usual manner.

Air piping from compressors if carried overhead, must be well supported so as to relieve the compressor cylinder of excessive and unnecessary strain. When making connections to the compressor be sure to make the piping size of equal diameter or larger than the pipe openings found on the compressor. The intake piping should be increased 1 in. in diameter for every 10 ft. in length. The air must be taken from a cool dry place free from dust, dirt or moisture.

Some Pipe and Pipe Fitting Facts

By W. F. Schaphorst

SCREWED FITTINGS are usually satisfactory for low pressure work and even for higher pressures where joints are carefully made. Seldom if ever, though, should the 6-in. pipe size be exceeded with screwed fittings. Larger sizes are liable to leak because of the difficulty of screwing up tightly. Beyond 6-in. sizes flanged fittings are always to be recommended.

After many years of confusion manufacturers and users of fittings have finally agreed on one standard—the "American Standard." To be safe, this standard should always be specified where possible. Complete data covering the American Standard are procurable from the American Society of Mechanical Engineers or from almost any recent mechanical engineering handbook.

To determine the approximate bursting strength of a fitting in lb. per sq. in. multiply the tensile strength of the metal by 6, multiply that by the thickness of the metal in the body of the fitting in inches, divide by the internal diameter of the fitting, in inches, and divide that result by 10.

In tightening bolts never slip a pipe over the wrench handle to increase leverage. Wrenches should always be short enough so that the bolt tightened will not be overstressed. A good rule to apply for determining the proper length of a wrench is to multiply the size of the bolt by 15. The result is the length of the wrench in inches.

Thus for a half-inch bolt use a 7½-in. wrench, for a 1-in. bolt a 15-in. wrench, a 2-in. bolt a 30-in. wrench.

For steam piping the factor of safety should be at least six.

The relative strength of piping is, roughly:

	Steel	Wrought Iron
Seamless, strongest	2	...
Lapwelded	1.9	1.1
Butt welded	1.5	1

Extra heavy pipe is better for bending in small sizes. It is not so liable to split and gives a rounder and better bend.

Riveted pipe is weaker than lapwelded pipe. Spiral riveted pipe averages about half as strong as lapwelded. Straight riveted pipe is weaker than spiral riveted, develops more friction and should not be used for hot water, live steam, or high pressure hot liquids or gases.

Copper and brass pipe is being used more and more because of its non-corrosive properties. Brass pipe in standard iron pipe sizes is most convenient to use although it is usually heavier, consequently more costly. The thinner tubing should not be used for high pressure work because it is not safe. Copper should not be used in high temperature work or high pressure service because it is not strong initially and it is greatly weakened by high temperatures. For example, it is only 85 per cent as strong at 360 deg. F., as at ordinary temperatures.

Control of Boiler Room Operation

OUTLINE OF INSTRUMENT AND CONTROL APPLICATION FROM A PAPER READ BEFORE THE N. A. S. E. CONVENTION. BY E. G. BAILEY

INSTRUMENTS and meters have played an important part in bringing about improvement in power plant efficiency during the past 10 yr. This statement is not made to detract in the least from the accomplishments due to improved types of turbines, boilers, stokers, furnaces and various auxiliary equipment but it should be remembered that in every-day service such equipment must be carefully checked as to its operating conditions and efficiency.

They bring out the important point that the improved efficiency to the switchboard from about 8 up to 22.6 per cent has been brought about by increasing furnace and steam temperatures, or in other words, conveying the B.t.u. from one point to another at a higher potential which is equivalent to high voltage for long distance transmission. Further economics have been brought about through the decrease in excess air and unburned fuel and also the lowering of the temperatures of escaping flue gases and the temperature of the exhaust steam to the condenser.

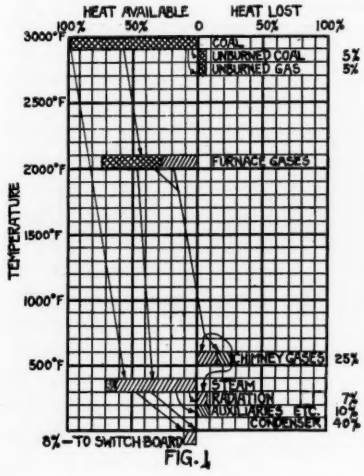


FIG. 1. HEAT BALANCE DIAGRAM FOR AN ORDINARY POWER PLANT IN 1920

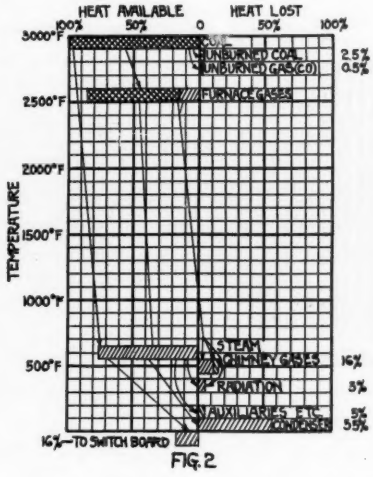


FIG. 2. HEAT BALANCE DIAGRAM OF THE BEST POWER PLANT IN 1920

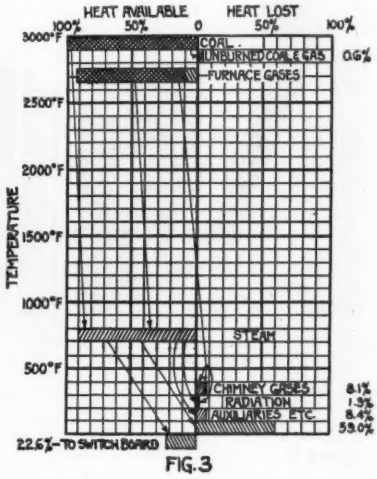


FIG. 3. HEAT BALANCE DIAGRAM OF BEST POWER PLANT IN 1924

Figures 1, 2 and 3 represent heat balance diagrams of the power plant, showing to a certain extent the development which has recently been brought about and is now going on. Figures 1 and 2 were prepared in 1920; No. 1 to represent the average power plant as near as could be ascertained, including large, small, good, bad and indifferent; while Fig. 2 represented the best power plant in 1920 and Fig. 3 applies to the best plants of today.

These diagrams have been prepared on a little different basis than usual, representing the heat available in different stages of the transmutation of heat units from the fuel to the switchboard on one side of the middle line and the losses in their various percentages on the other.

It is evident that there has been an increase in the percentage of total heat in coal lost through the condenser which is brought about by better boiler room efficiency. The present tendency toward stage reheating will bring about a further change in this figure, lowering it so that the boiler plant will have to look for its efficiency elsewhere than heating feed water in the economizer, perhaps going to the air heater which will in turn increase the temperature of the furnace gases and perhaps still further reduce the percentage of excess air and thereby

bring about a bigger temperature drop between the furnace and the chimney gases.

Outline of Boiler Room Instruments

In order to illustrate the application of meters to the various points in a boiler room, reference is made to Fig. 4, which illustrates diagrammatically modern steam generating equipment in its most complete form, consisting of boiler, superheater, economizer, air heater and forced and induced draft.

The specific problem before the operator of such equipment is to supply the demand for steam at best efficiency. To obtain the desired capacity the steam pressure is a guide indicating the balance between the B.t.u. required for the turbine or other works and the input of B.t.u. brought about by the combustion of fuel.

and forced draft chain-grate stokers, as well as pulverized fuel and various oil and gas burners. Then the chimney damper or the induced draft fan must be controlled to carry away the gases and products of combustion.

Steam pressure is the guide for the fuel supply. The guide for air supply is the proper relation between fuel and air, as shown by flue gas analysis, excess air, or the relation between steam flow and air flow. The guide for the control of induced draft is the furnace pressure as an indication of taking the gases away as fast as they are brought within the furnace in order to prevent too great a suction or too much pressure at this point.

Excess Air Must Be Reduced

One of the most important phases of combustion efficiency is the determination of excess air. Years ago plants

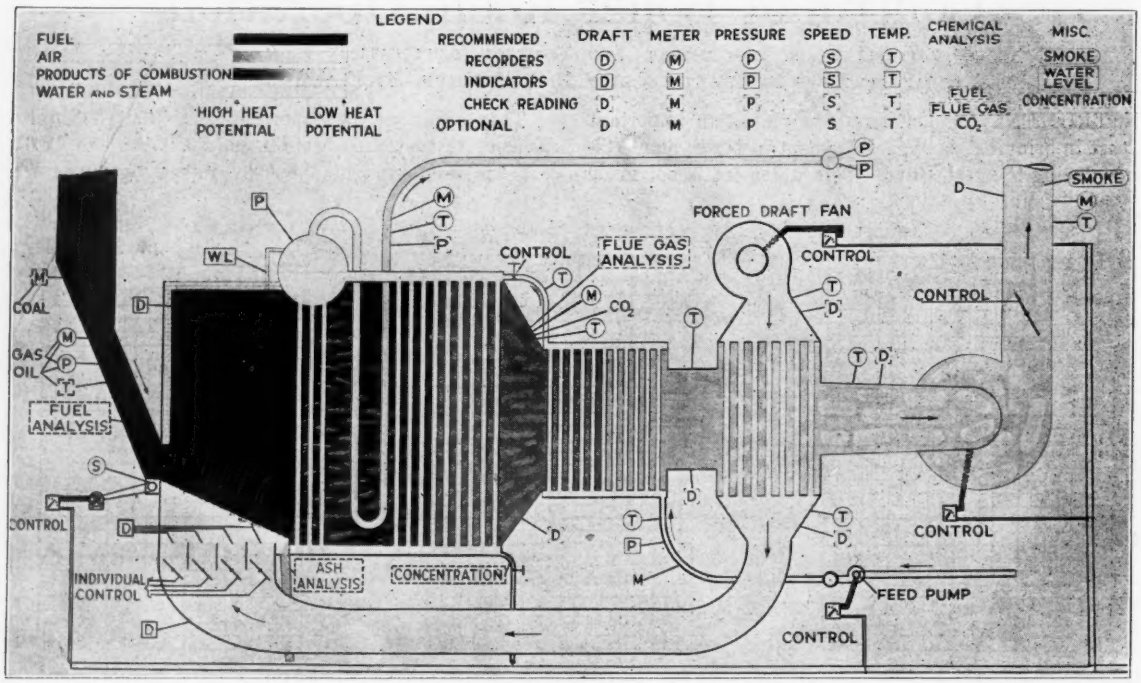


FIG. 4. DIAGRAM SHOWING LOCATION AND TYPE OF INSTRUMENTS WHICH MAY BE USED IN BOILER ROOM CONTROL

Steam pressure can be maintained by the supply of fuel and air regardless of combustion efficiency or good heat absorption. The best combustion efficiency is brought about by completely burning the fuel with a minimum excess air, creating a high heat potential or high furnace temperature so as to get good and complete transfer of heat from the gases to the water system in the boiler and economizer.

On this diagram certain control points are noted to bring about the proper operation for both capacity and efficiency. Starting with the feed system, the main feed pump or pumps should be controlled to maintain a substantially constant pressure, or a constant difference in pressure between the feed line and the boiler. From this main feed header the control to individual boilers is brought about to maintain the water level as desired, thereby reducing that which is evaporated as steam.

Forced draft and the fuel must be under control and perhaps the air supply under individual distribution control as in the case of different compartments in underfeed

were operated with 50 to 100 per cent and in many cases even greater amounts of excess air and yet at the same time through the intermittent or unequal distribution, large percentages of heat were lost by unburned fuel to the ash pit and unburned gases to the stack. The biggest improvement in our boiler efficiency has been brought about by better stoker and larger furnace construction, as well as proper guidance of the operation to obtain the minimum total loss in excess air and unburned fuel, consistent with maintenance of brick work and refractory.

One of the biggest problems before the boiler operator today is the maintenance of refractory material. Excess air has been brought down from well up toward 100 per cent to less than 40 per cent in practically every case and most of the best stokers and pulverized coal plants are now operating with between 20 and 30 per cent excess air, while the oil and gas fired furnaces are down to from 10 to 15 per cent and in no cases are large losses permitted in unburned fuel.

It is, therefore, evident that the proper determination of excess air is of prime importance. While flue gas analysis showing CO_2, oxygen and unburned gases is, and probably always will be, the basis of comparison of results, such flue gas analysis should be used largely as a periodic check upon other equipment and for studying the stratification of gases and other special problems. As we have crowded down on excess air and approached closer to the unburned gas limit, the CO_2 recorder has shown up its limitations and recorders showing both CO_2 and unburned gases are more to be desired.

It is well known today that practically all commercial fuels require the same amount of air per thousand B.t.u. developed when burned at a definite percentage of excess air. This, therefore, leaves a close relation between the amount of air used for combustion and the amount of steam produced from such combustion. Therefore, a ratio of the steam flow from the boiler and the air, or rather the products of combustion as they pass through the boiler so as to include all air regardless of whether it enters through the grate, primary or secondary air or otherwise, gives the desired result in a relation between the fuel which can be established for the desired percentage of excess air which may be different at various ratings. That is, with stoker fired boilers it may be desirable to carry 50 per cent excess air at low ratings and as low as 20 per cent excess air at high ratings, while with pulverized coal in order to preserve the brick work and maintain a substantially constant furnace temperature it may be desired to run 20 per cent excess air at low ratings and as high as 30 or 35 per cent excess air at high ratings.

In regard to meters, as shown in Fig. 4, it is not always possible to meter the fuel accurately but some indication of the rate should be obtained in every case possible, while the total amount of fuel should be checked periodically with great accuracy in order to determine the total station efficiency.

Feed water should be metered in, or the steam out from the boiler. As both of these results should agree there is little choice except it may be better to meter steam as it shows the instantaneous changes in load more closely than does the feed water and also avoids any tendency to show high evaporation due to blowing down or leakage of any kind. In other words, the steam flow meter shows the actual output of useful steam.

In the way of pressures, the feed pressure and the boiler drum pressure should of course be indicated as usual and the pressure in the main header recorded also. The speed of stokers, fans and pulverized coal feeders is useful as an operating guide and also where motor-driven auxiliaries are used an ammeter is useful in checking up the operation of such equipment.

Temperatures Indicate Heat Transfer

Temperatures are an extremely important factor in boiler operation, especially with the water and the gases in showing the heat transfer. It is, of course, desirable to know the superheat temperature and this is especially important with certain types of radiant superheaters where the temperature much be carefully watched.

Few people waste time arguing over the advantages of recorders compared with indicating meters on the essential factors of boiler operation and efficiency. Generally there should be as few recording instruments as possible, yet the important results should by all means be recorded instead of merely indicated, as they are a much better check on the operation even to the operator himself at the instant of watching the records, because he can see whether it is increasing or decreasing.

While the diagram as given would apparently call for a large number of meters and instruments yet for this complete equipment all records, exclusive of those in the main stack, can be recorded on three charts. The first and most important could record the steam output, the rate of fuel feed, the rate of air flow; the second could record the temperature of gases leaving the boiler, leaving the economizer and leaving the air heater, as well as the air leaving the air heater and the third could record the temperature of feed water entering and leaving the economizer and the superheat, making ten records on three charts all of which are so inter-related to the other records on the same chart as to give much more valuable information than if they were recorded on individual charts.

Various drafts, pressures and temperatures of secondary importance can all be indicated on different types of gages in compact form so as to occupy little space on the meter board and also be readily comparable one with another, especially the draft in different sections of a chain-grate stoker.

Heating with Waste Gases

Recent tests and developments in the preheating of combustion air by waste gases have shown that in the future, the installation of this type of equipment should be considered in the study of the heat balance of a power station.

An experimental installation at the Colfax power station was recently tested. The Duquesne Light Company advises as follows:

"These tests have shown that it is possible to secure improved boiler performance, as well as improved combustion results by the use of preheated air. Air temperatures up to approximately 240 deg. F. were used and a total improvement in gross boiler efficiency up to 7 per cent was shown over the operation of the same boiler without the air preheater. This improvement will result in a decrease in coal consumption of 9 to 10 per cent, less the increased power consumption for induced and forced draft. The improvement in boiler efficiency was higher than the improvement which could be attributed to the higher heat content of the air supplied for combustion. This evidently resulted from improved fuel bed conditions as well as a slightly better performance of the boiler heat-absorbing surface, the exit gas temperatures were lower, probably due to the higher furnace temperatures.

The limited experience gained to date with the use of preheated combustion air has shown that material improvement in boiler plant efficiency can be accomplished with such installations without material increase in the maintenance of stokers, refractories, etc. This experience has been mainly derived from installations utilizing stack gases for heating the combustion air, and equipment for this purpose has been designed along a variety of different lines.—N. E. L. A. Prime Movers Report, 1924.

Plant in Utah Uses Pulverized Coal

THIS METHOD OF FIRING WAS INSTALLED TO OBTAIN MORE STEAM FROM EXISTING BOILERS. BY JULIUS C. BILLETER

DURING THE last few years great progress has been made in the application of pulverized coal to the firing of steam boilers. In nearly every state there are some plants, which are now fired by pulverized coal. The success attained has been varied. Of several installations in Utah, a most successful one was finished in the fall of 1923 in a sugar factory at Layton, 27 mi. north of Salt Lake City.

This plant had been satisfactorily fired by hand for a number of years but as the load, which consists essentially of sugar pans, evaporating vats and numerous steam engines increased, it became difficult to supply the power needed. The problem was augmented by the fact that the biggest loads, those of the sugar pans and evaporating vats, constantly fluctuate and require instantaneous service with only short notice to the fireman.

In seeking a remedy, all factors were studied and finally it was decided to install pulverizing equipment. The decision was governed not only by the necessity to get considerably more steam out of the same boilers but also by the fact that the time of installation was comparatively short as the plant had to be in operating condition as soon as the first sugar beets were delivered to the factory. This being a comparatively small plant, the unit system was decided upon.

Coal cars dump the coal (mostly slack) on to huge coal piles close to the boiler room. Below these coal piles are screens through which the coal must pass before it is deposited in the pits below them. Three bucket elevators located just outside of the boiler room take the coal from the pits and lift it through a vertical distance of 30 ft. A larry weighs the coal and then it is conveyed to three storage tanks. These tanks are 10 ft. high, have a diameter of 12 ft. and store enough coal to supply two boilers for a 2-hr. run at full load. Each tank serves two boilers through two independent pulverizers.

In all there are six pulverizing machines, one for each boiler and they are driven from the same driveshaft, but may be disconnected from it whenever that machine is not in use. The pulverizer proper consists essentially of a cylindrical housing containing a rotor mounted on a shaft, the rotor being composed of pulverizing elements and a fan. Here the coal is reduced to powder and by means of a valve the air accompanying the coal from the pulverizer to the furnace can be regulated to suit practically any condition. No provision exists for the drying of coal before going to the pulverizer. The pulverizer feeds the coal to the boiler through four inlet pipes leading through the front furnace door. Above the inlets are shutters through which additional air may be supplied.

FURNACES ARE BUILT WITH FRONT EXTENSION

Six B. & W., Stirling-type boilers are installed which have a rated capacity of 400 hp. each at 125 lb. pressure. An additional arch furnace in front gives the boilers the appearance of Dutch ovens. The flame is directed downward in order to give it ample combustion space before the water tubes are reached. The temperature in the front part of the boilers is about 4000 deg. F., while in the back part the temperature is only 2100 deg. F.

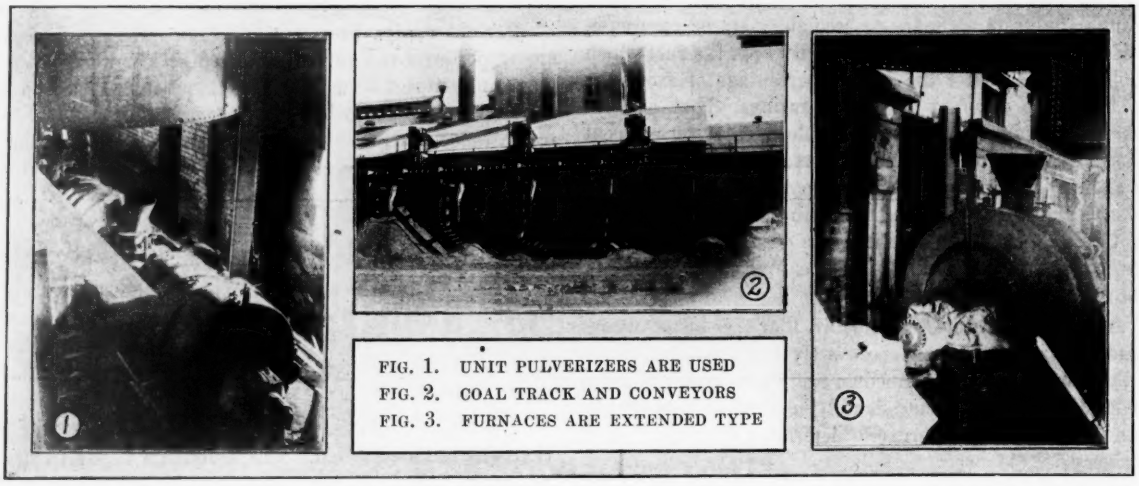


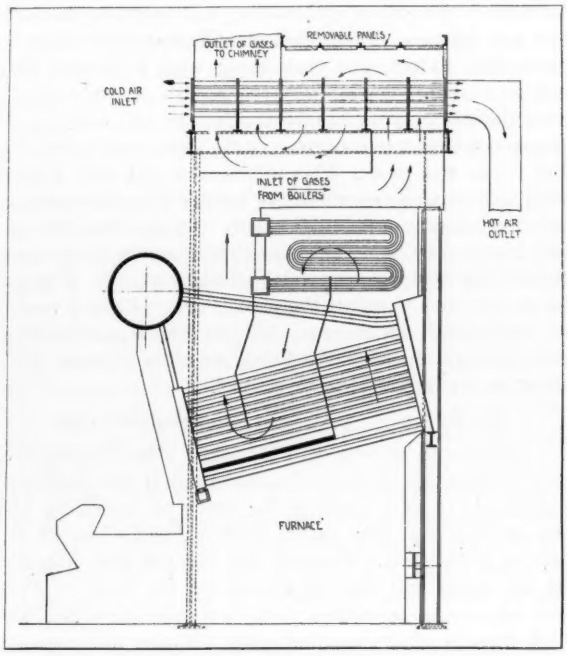
FIG. 1. UNIT PULVERIZERS ARE USED
FIG. 2. COAL TRACK AND CONVEYORS
FIG. 3. FURNACES ARE EXTENDED TYPE

This plant has been working successfully with the arrangement described above except some difficulty was encountered in disposing of ash and coal dust. The flues must be constantly cleaned. This is done by turning a hose with live steam into the flues. The residue is removed through cleanout doors and is hauled out in a wheelbarrow. An examination of the residue shows little slag but considerable coal dust. This condition may be partly accounted for by the fact that the boilers are continuously running at 200 per cent rating or more.

While one man hauls the ashes and dirt away, another cleans the flues and looks after the machinery, which consists essentially of pulverizers and a steam engine. This engine is of modern construction, drives the machine shops, auxiliary pumps, boiler feed pumps and the shaft which furnishes power to the pulverizers. The load on the engine is materially increased whenever coal with a high percentage of moisture is used, this being due to the added power demanded by the pulverizers.

Air Preheater Uses Rectangular Elements of Cast Iron

INCREASED efficiency of a boiler plant due to the use of preheated air has recently attracted a great amount of attention, both from the viewpoint of design and practical operation. The construction of the heater must be such that it will offer a comparatively small resistance to both the flow of air and waste gas and still result in the maximum possible heat transfer. Materials must be so selected that they will successfully withstand the conditions under which they must be used and the various units of which the heaters are comprised must be so joined and



HEATER EXTENDS ACROSS THE FULL WIDTH OF BOILER SETTING

assembled that the gas and air will not come in intimate contact.

These conditions being satisfied, the results which can be expected from the use of preheated air are: greater furnace and boiler efficiency; the use of lower and cheaper grades of fuel and the reduction in size or the practical elimination of the customary ignition arches which are commonly employed in furnace design where air at ordinary room temperature is used to support combustion.

For these reasons modern power station practice is tending more and more to the use of air preheating, especially as the higher steam pressures now being employed and the policy of inter-stage feed water heating, are diminishing the field for economizers, thus indicating the necessity for some other method of utilizing the heat of the flue gases.

In a recent issue of Engineering of London there is described the E. Green & Son air preheater which is applied as shown in the accompanying sketch. In America, sheet steel, steel tubes and cast iron tubes have all been used in the construction of air preheaters. In this English development use is made of cast iron but the cross section of each element deviates from former practice in that it is rectangular.

This air preheater is built up of elements grouped together in series and parallel. Each element consists of four rectangular tubes cast in one piece and connected together by a flange at each end. The flange is 10 in. long by 5½ in. wide. The tubes are 30 in. long, 4 in. deep, 1 in. wide and are 1½ in. apart, the complete element having 9.46 sq. ft. external heating surface and 8.33 sq. ft. internal heating surface. The flanged faces of the elements are finished by machining or grinding and are held together by bolts.

Outside flanges on the air inlet and outlet sides are bolted to an airtight sectional framework with a converging mouthpiece opposite each tube, in order to prevent undue eddying of the air. Each element weighs about 80 lb. and is heavier than sheet metal construction of the same heating surface. Each element occupies a space of 1 cu. ft. and a series of elements which, with their casing, need not occupy a greater height than 3 or 4 ft. can be arranged to supply the requisite quantity of heated air to the grate of a water-tube boiler.

Construction of this kind readily lends itself to a shallow arrangement of the elements, by extending them across the full width of the furnace. The flue gas sweeps the flat surfaces of the tubes transversely, passing through the heater in streams, 1⅛ in. thick and 29 in. wide. The air passes longitudinally through the inside of the tubes, in streams 1 by 4 in. in cross section. The contra-flow principle has been adopted, the air passing from the cooler to the hotter portion of the heater on its way to the furnace. It should be noted that in the sketch the heater is baffled so that the hot gas makes three passes over the heater tubes.

Experiments have been carried out to determine the rate of heat transmission through heating elements of this type. These show that the number of B.t.u. transmitted per hour per degree difference in temperature between the gas and the air, varies from 1.8 for an air velocity of 1000 ft. per min. to 3.3 for an air velocity of 2500 ft. per min. These rates are practically the same as those obtained with sheet iron heaters.

Getting the Most Out of Soot Blowers

LOWER STEAM CONSUMPTION AND LESS MAINTENANCE COST WILL RESULT FROM MORE INTELLIGENT USE OF SOOT BLOWERS

MOST of the information published about mechanical soot blowers deals with the improvements and what they save. What engineers need more, because it is a matter over which they have control, is how to get the most out of their soot blowers by more careful and intelligent operation.

When more intelligence is shown in the use of mechanical soot blowers they will last longer, consume less steam, require fewer repairs and prove an even better investment than they are now. A few of the conditions encountered in many plants may serve to attract attention to this important matter.

Steam consumed by the blowers can often be cut in half and usually reduced at least 25 per cent by more

careful and intelligent blowing. The steam consumption per blower element at a given steam pressure should be known, as well as how long each element should be opened, so that the total steam consumption for the entire operation of soot removal may be determined either by actual measurement with steam-flow meter (difficult to obtain accurately because of the low-scale deflection) or by calculation from Napier's formula:

$$W = \frac{P\ a}{70}$$

Where W equals lb. of steam flowing per second
p equals absolute pressure per sq. in.
a equals area of orifice in sq. in.

Not all nozzles require the same time to do their work. Some have less work to do than others. This fact should be self-evident. Yet it is a fact often overlooked. The nozzles nearest the fire, that is, those nearest the front row of tubes, have the hardest work to do because ash, carbon and fuel-gas dust impinge directly upon them. They do, therefore, ordinarily need to be operated the more often and kept open longer.

The engineer who watches his equipment and uses his instruments will often find that the first two elements require only 30 sec. once a day. Of late boilers are being set to absorb an increasing amount of heat from the furnace as radiant energy, which means the first few rows of tubes do an increasingly great amount of work. The front element should be used oftener, therefore, in the endeavor to utilize fully the radiant heat available.

If there are 16 elements and each consumes 450 lb. of steam per minute at 250 lb. gage, with steam costing 45 cents per 1000 lb., it is readily seen that to operate these elements 60 sec., instead of the 30 sec. that may suffice, causes a needless loss of $1.62 per day. Based upon six days a week, every week in the year, it can be seen that this one item of $421 alone would go a long way toward paying for renewals—or an increase in wages for the engineer.

It is well to differentiate between the boiler and superheater elements because to blow both when only the one set needs blowing is to waste steam. The thermometer in the steam line to show the degree of superheat, will quickly show when the superheater element needs to be operated. The degree of superheat as well as the steam temperature gradually falls as the stack temperature gradually rises with the accumulation of soot.

A thermometer in the steam line often indicates that the superheater element can be used to advantage where the boiler elements do not need to be used. As it is not uncommon to find a decrease of 25 deg. in superheat within 48 hr. of continuous operation where soot blowers are not used, it can be seen at once that closer attention to the superheater element is well worth while.

Some boilers require soot blowing twice a day, for others every other day suffices, while for others once a week is adequate.

Maintenance

Maintenance costs can be reduced greatly by more careful operation on the part of the boiler room force; heating of the elements due to their location cannot be prevented but the effect can be combated; it is inherent to their location. But the avoidance of water and moisture in the steam should be religiously undertaken under all circumstances.

Wet steam and slugs of water resulting from inadequate design, improper installation or defective drainage are often the major causes of depreciation, failure and consequent high upkeep cost. This explains why one station will have a maintenance cost so much higher than another with apparently identical conditions. In many instances the maintenance and replacement costs directly chargeable to wet steam and slugs of water exceed the cost of all other items of expense combined. This fact cannot be stressed too strongly or too frequently, particularly to new men and men who have never before operated mechanical soot blowers.

It certainly would pay to tabulate the various items involved in the cost of maintaining and operating mechanical soot blowers. These data should record the date repairs were started, and completed; what work was done and to which elements; why the repairs or replacements were necessary; what caused the failure and anything of special significance connected with them, and when the last repair was made. This information not only gives a good indication as to where the trouble lies—in manufacture, in installation and operation—but it is the first real step toward alleviating or eliminating the underlying cause. Such a log would be surprising in many plants. It would be an indictment against the plant personnel and a verdict of "not guilty" for the manufacturer who is now so often compelled to shoulder the blame and the expense for a situation he is powerless to control.

Lessening Puffing and Smoking of Fires

Disturbance of soot and ash that often accompanies soot blowing can be lessened considerably if not eliminated entirely by always opening the stack or breeching and ash-pit dampers wide before blowing, regardless of the rate of combustion. The soot and flue-gas dust liberated by the steam will then be carried up the stack by their own impetus, to be carried on their way by the draft. The high velocity of the upgoing gases will also minimize the amount of flue-gas dust and soot redepositing upon the boiler surfaces.

Where soot blower elements blow in a direction opposite to the flow of gases up the stack, puffing and smoking of fires may persist. Keeping stack and ash-pit dampers wide open minimizes this, however, and lessens the amount of dust that may resettle upon the surfaces within the boiler passes.

It ought hardly to be necessary to point out that the lowest element, which is that nearest the fire, should be operated first, each element in the direction of gas-flow being taken in consecutive order.

Improvements and refinements in mechanical soot blowers should not be allowed to bring about less care in using them. Rather, they should be used to encourage greater care in the effort to bring about longer life, lower maintenance costs and higher over-all economy. It is, perhaps "up to" the soot blower manufacturers to drive these facts home.

When a shipment of wire rope is received and is not to be placed immediately into service, see that it is stored away in a place protected from the weather and any acid fumes. It is advisable to coat the outside layer of the reel or coil with a good lubricant.

ELECTRICAL MACHINERY FOR LIGHT AND POWER

Phasing Out Synchronous Motors

AN INTERESTING EXAMPLE OF THE APPLICATION OF VECTORS IN SOLVING A PRACTICAL PROBLEM. BY J. A. CAPARO

MOST PRACTICAL ELECTRICAL men are familiar with the use of vectors in the analysis of alternating current problems. The following instance is an interesting example of how vectors may be applied to the solution of some practical problems which often come up in the power plant.

In a certain plant in which several synchronous generators were installed it was desired to operate a three-phase synchronous motor coupled to a direct-current generator in order to supply the required excitation for the fields.

Little was known regarding the constructional features of the motor, in fact the only available information was that contained in the name plate, i. e., 440 v., 3-phase, 8-pole, 60 cycles, 60 hp. The machine had a stationary armature and revolving fields. Besides the two terminals for the excitation of the motor fields from the storage battery source, there were six other pairs of terminals coming directly from the armature. These came out in such a way that it was impossible to trace the windings without dismembering the motor. The problem now was to determine the proper connections to operate the motor under normal conditions.

To do this the motor was first driven as a generator at a speed, as computed by the use of the formula

$$N(\text{RPM}) = \frac{120f}{P} = \frac{120 \times 60}{8}$$

or 900 r.p.m. Using the direct current side as a motor excitation was applied until the voltage across one pair of opposite terminals showed 50 v. Let the accompanying diagrams show the six pairs of terminals from the armature, and let e_1 and e_2, etc., represent the voltage per terminal, with the arrows arbitrarily chosen to represent the direction of the positive maximum value of alternating e.m.f. as a point of the field, say the middle of a north pole sweep past a point on the periphery of the armature.

By means of a voltmeter it is found that $e_1 = e_2 = e_3 = e_4 = e_5 = e_6$, numerically. If now we connect the terminals "a" and "d," and measure the voltage across cb, we obtain 96.59 v. That that is so is easily seen by referring to the arrows in Fig. 2; $e_1 + e_2 = 96.59$ v. and similarly, connecting "d" and "e" we get $e_2 + e_3 = 96.59$ v. numerically. If 1 and 2, or any of the following pairs of coils, 2-3, 3-4, 4-5, 5-6, were in phase, then the result of the test outlined above would be 100 v. instead of 96.59. There is then an angular difference between e_1 and e_2, and since each is 50 v. we have the three sides of an isosceles triangle, namely, 50; 50, 96.6, as shown in Fig. 2.

Solving the triangle, it is found that the angle between e_1 and e_2 is 30 electrical degrees. In the same way the angle between e_2-e_3, e_3-e_4, e_4-e_5, e_5-e_6 is found to be 30 deg. As a check, connect b and g, and measure the voltage across ah. This is found to be 70.5 v. Thus we have again the three sides of an e.m.f. triangle, namely, 50, 50, and 70.7, which when solved gives an angle of 90 deg. between the two vectorially added e.m.f.'s, namely, e_1 and e_4.

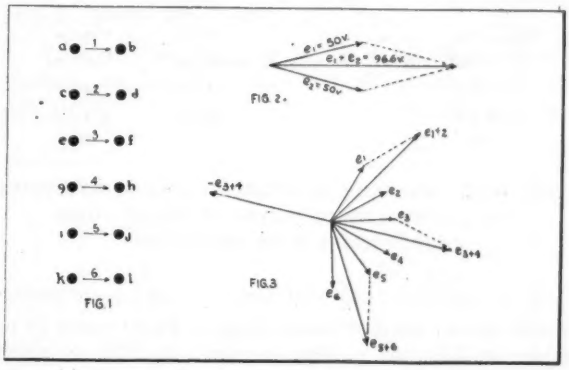


FIG. 1. TERMINAL BOARD ON MOTOR, SHOWING 6 PAIRS OF LEADS

FIG. 2. VECTOR DIAGRAM SHOWING HOW THE TWO VOLTAGES ARE ADDED VECTORIALLY

FIG. 3. VECTOR DIAGRAM SHOWING THE RELATIONS OF THE VARIOUS E.M.F.'S

The complete vector diagram of e.m.f. can now be drawn by the lines e_1, e_2, e_3, e_4, e_5, e_6, of the diagram shown in Fig. 3.

It must be stated that each vector represents the e.m.f. developed by eight coils so placed around the armature that their electromotive forces are in phase, and hence added by arithmetic to render 50 v. under this excitation.

Having discovered the phase displacement of the coils, we now proceed in a more general way to show how the vector diagram of e.m.f. is used to determine various schemes of connections.

CASE OF A Y CONNECTION OF MAXIMUM TERMINAL VOLTAGE

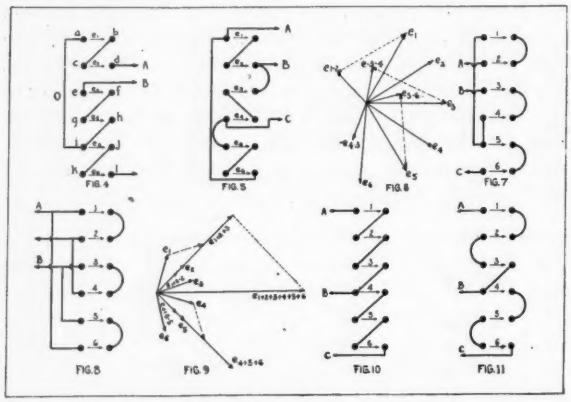
In order to obtain a maximum terminal voltage with the least excitation we combine these e.m.f.'s in three pairs, each pair consisting of two e.m.f. whose angular displacement is the least, connected in series.

This argument leads to the combination $e_1 + e_2 = e_{1+2}$, $e_3 + e_4 = e_{3+4}$, $e_5 + e_6 = e_{5+6}$. It will be noticed that the

angular displacement of e_{1+2}, e_{3+4}, e_{5+6}, is 60 deg., respectively, hence reversing e_{3+4} we obtain three equal e.m.f.'s with a phase displacement of 120 deg.

Referring now to the terminal board we connect the points b-c, f-g, j-k, and we have e_{1+2} across a-d. Let the numerical value of each terminal e.m.f. e_1, e_2, e_3, etc., be represented by e, then $e_{1+2} = e_{3+4} = e_{5+6} = 2e$ cos. 15 as can be easily seen from the vector diagram shown in Fig. 3.

In order to obtain a Y connection, select a neutral point such as 0 (Fig. 4), and trace the arrows in board diagram positively, that is, in direction of arrows for e_{1+2} and e_{5+6}, since they are 120 deg. apart, and negatively, or opposite to the arrows, to obtain vector—e_{3+4} which, being the reverse vector e_{3+4} is also 120 deg. from the other two.



FIGS. 4-11. DIAGRAMS SHOWING VARIOUS CONNECTIONS AND THE VECTORS BY MEANS OF WHICH THESE CONNECTIONS WERE DETERMINED

It is apparent then that the line e.m.f.'s across terminals A.B.C. are numerically equal to $2\sqrt{3}e$ cosine 15 or 3.345e or if e = 50 v., then the e.m.f. is 167.3 v., which means that the excitation is to be increased until this voltage reaches the normal value of 440 v.

A Delta Connected Circuit

If a delta circuit is desired, trace the vector diagram in such a way that the resultant of two of the phase e.m.f.'s, e_{1+2} e_{5+6} is equal and opposite to the third e.m.f. in the triangle of e.m.f., thus formed. This makes the resultant e.m.f. in the local circuit of the delta zero. This leads us to the following scheme, $e_{1+2} + e_{5+6} = e_{3+4}$ tracing the circuit of the terminal board as suggested by this formula, we get the connections shown in Fig. 5.

If, instead of adding the electromotive forces of smallest angular displacement in pairs of two, we should subtract e.m.f.'s, we obtain: e_{1-2} e_{3-4} e_{5-6} shown in vector diagram, Fig. 6. Now is e_{3-4} is reversed, we have three e.m.f.'s at 120 deg. from each other, which may now be connected to form either a Y or a delta scheme of minimum value.

The Y Connection

In the case of a Y, the value of the phase e.m.f. e_{1-2}, e_{3-4}, e_{5-6} is 2e cosine 75 deg. $= 2 \times .2588e = .5176e$, and that of the line e.m.f. across terminals A, B, or C is $2\sqrt{3}e$ cosine 75 deg. or with e = 50, this voltage becomes 44.8 v. The terminal board of connections for the last arrangement is shown in Fig. 7.

Following the same scheme, we can determine the connection of minimum voltage for a given excitation. This is shown in Fig. 8.

Two Phase, Maximum

Since vectors e_2 and e_5, Fig. 9, are at right angles and since the vectors e_1, e_3, and e_4, e_6 are symmetrically placed with respect to the former, the combination $e_1 + e_2 + e_5 = e_{1+2+3}$ is at right angles from $e_4 + e_5 + e_6 = e_{4+5+6}$. This suggests the two phase connection of maximum numerical value as shown in Fig. 10. The numerical value of this phase voltage is

2.e. cosine 30 deg. + e = e(2 cos. 30 + 0.1) = 2.732e

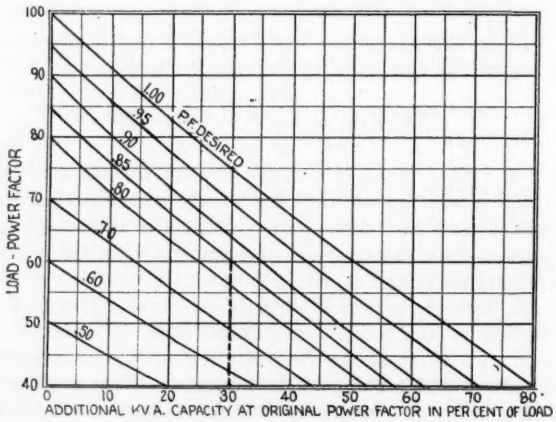
If we subtract vectors e_2 and e_5 from the combination $e_1 + e_3$ and $e_4 + e_6$ we obtain another combination of two vectors $e_1 - e_2 + e_3$ and $e_4 - e_5 + e_6$ which are at right angles. The scheme of connections is shown in Fig. 11, and the numerical value of the electromotive force is

2.e. cos. 30 — e = e (2 cos. 30 — 1) = .732e

Similarly other combinations are easily worked out. The scheme is based on the hypothesis that the vectors in a clock diagram which represent positive direction, say of the maximum voltage, are represented in the terminal board diagram by arrows all pointing in the same direction, arbitrarily selected, so that any combination on the vector diagram, if followed out, upon the terminal board diagram, will give the desired result.

Figuring the Size of a Static Condenser

STATIC condensers are being used to a considerable extent for improving low power factor conditions on comparatively small systems. These condensers may be obtained for installation on circuits ranging in frequency from 40 to 125 cycles, in voltages from 220 to 2300 v. and in capacities from 60 kv.a. to 300 kv.a.



ADDITIONAL CAPACITY OBTAINED BY INCREASE OF POWER FACTOR

When considering the installation of a static condenser for correcting power factor troubles, it is well, first, to conduct a thorough investigation to determine to what extent the troubles can be corrected by the presence of leading currents in the system. A survey should be made of all generating capacity in both energy and kv.a., average and maximum load, power factor of generators, feeders, and distribution system.

In any installation of this type it is desirable to locate the static condenser as near the source of the reactive load as possible in order to avoid the transmission of wattless current. Because of this it is often more economical to install a number of relatively small condensers than one large one. For this application the static condenser is admirably suited, as the question of attendance need not be considered. With the location determined, the load and power factor within its zone determined, the proper size of condenser to raise the power factor to a given value can be calculated in accordance with the following example:

Let us assume a plant with a load of 330 kw. at 0.60 power factor; it is desired to raise the power factor to 0.85.

A 330-kw. load at 0.60 is $330 \div 0.6 = 555$ kv.a. apparent load which has a wattless component lagging $\sqrt{555^2 - 330^2} = 446$ kv.a. A 330-kw. load at 0.85 $= 330 \div 0.85 = 388$ kv. a. apparent load that may be expected when the condition of 0.85 power factor is realized. This has a wattless component lagging of $\sqrt{338^2 - 330^2}$ $= 73$ kv.a. The difference $446 - 73 = 373$ is the leading kv.a. that will be necessary to raise the power factor of the load to 0.85. The largest standard size condenser available is 300 kv.a., so for this installation we will need two condensers, one of 300 kv.a. capacity and another of 60 kv.a., giving a total of 360 kv.a. This is slightly less than the capacity required but is the nearest capacity available without considerably exceeding the required value.

It will be found that additional capacity in the line will be made available by installing a static condenser. In the accompanying illustration is shown a chart which gives the additional capacity available by an increase in power factor.

Assume the load is 330 kw. at 0.6 power factor and that 0.85 power factor is desired. The projection of the intersection of the 0.6 power factor line with the 0.85 curve, gives the kw. load at 60 per cent power factor made available at 85 per cent power factor as 0.30×330 kw. $=$ 99 kw.

Electric Temperature Indicators

PRINCIPLES OF POTENTIOMETER AND RESISTANCE TYPES OF MEASURING EQUIPMENT. BY I. MELVILLE STEIN*

IN measuring the temperature of electrical machinery two types of temperature detectors have been employed, one the resistance coil detector, which is usually measured by a balanced Wheatstone Bridge, and the other, the thermocouple detector, measured by a balanced potentiometer bridge. In view of the many uses to which these instruments are put, it may be well to study briefly the principles upon which they operate.

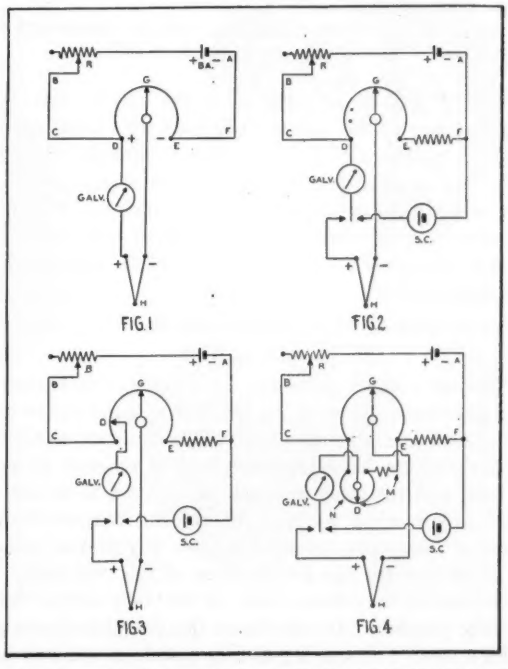
The potentiometer is the electrical equivalent of the chemical balance, or balance arm scales. Measurements are made with balance scales by varying known weights until they equal the unknown weight. When the two are equal, the scales stand at zero; that is, in the position which they occupy when there is no weight on either pan; the scales are then said to be balanced. Measurements are made with the potentiometer by varying a known electromotive force until it equals the unknown; when the two are equal the index of the potentiometer, the galvanometer needle, stands motionless as it is alternately connected and disconnected. The variable known weights are units separate from the scales but the potentiometer provides its own variable known electromotive force.

The potentiometer provides, first, a means for securing a known variable electromotive force and, second, suitable electrical connections for bringing that electromotive force to a point where it may be balanced against the unknown electromotive force of the couple. The two are connected with opposite polarity, or so that the two e.m.f.'s oppose one another. So long as one is stronger than the other, a current will flow through the couple; when the two are equal, no current will flow.

Figure 1 shows the wiring of the potentiometer in its simplest form. The thermocouple is at H, with its polarity as shown by the symbols + and —. It is connected with the main circuit of the potentiometer at the fixed point D and the point G.

*The Leeds & Northrup Co.

A current from the dry cell Ba is constantly flowing through the main, or so-called potentiometer circuit, ABCDGEF. The section DGE of this circuit is a slide

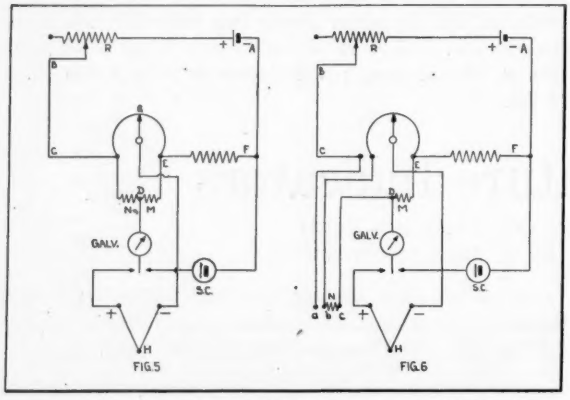


FIGS. 1—4. DIAGRAM SHOWING WIRING OF POTENTIOMETER

wire, uniform in resistance throughout its length. The scale is fixed on the slide wire. The current from the cell Ba, as it flows through DGE, undergoes a fall in potential, setting up a difference in voltage, that is, an electromotive force, between D and E. There will also be electromotive force between D and all other points on the slide wire. The polarity of this is in opposition to the polarity of the

thermocouple which connects into the potentiometer at D and at G. By moving G along the slide wire a point is found where the voltage between D and G in the slide wire is just equal to the voltage between D and G generated by the thermocouple. A galvanometer in the thermocouple circuit indicates when the balance point is reached, since at this point the galvanometer needle will stand motionless when its circuit is opened and closed.

The voltage in the slide wire will vary with the current flowing through it from the cell Ba and a means for standardizing this is provided. SC, Fig. 2, is a cadmium cell whose voltage is constant. It is connected at two points, D and F, to the potentiometer circuit whenever the potentiometer current is to be standardized. At this time the galvanometer is thrown in series with SC. The variable



FIGS. 5—6. POTENTIOMETERS WITH AUTOMATIC COMPENSATORS

rheostat R is then adjusted until the current flowing is such that as it flows through the slide wire DGE and the standard resistance EF, the fall in potential between D and F is just equal to the voltage of the standard cell SC. At this time the galvanometer will indicate a balance in the same way as when it was used with a thermocouple. By this operation the current in the slide wire DGE has been standardized.

Development of Wiring Scheme of the Cold End Compensator

The net voltage generated by a thermocouple depends upon the temperature of the hot end and the temperature of the cold end. In this discussion, the end exposed to the temperature to be measured will be referred to as the hot end, and the other end will be referred to as the cold end. Any method adopted for reading temperatures by means of thermocouples must in some way provide a means for correcting for the temperature of the cold end. The potentiometer may have either of two very simple devices for this purpose. In one form the operator is required to set a small index to a point on a scale corresponding to the known cold junction temperature. In the other form an even more simple automatic compensator is employed. The principle of each is described in the succeeding paragraphs, in which the assumption is made that the reader already understands the potentiometer principle as described above.

As previously explained, the voltage of the thermocouple is measured by balancing it against the voltage drop DG in the potentiometer.

As shown in Fig. 2, the magnitude of the balancing voltage is controlled by the position of G. Make D movable as shown in Fig. 3 and the magnitude of the voltage DG may be varied either from the point D or the point G. This gives a means for compensating for cold end changes by setting the slider D. As the cold end temperature rises the net voltage generated by the couple decreases,

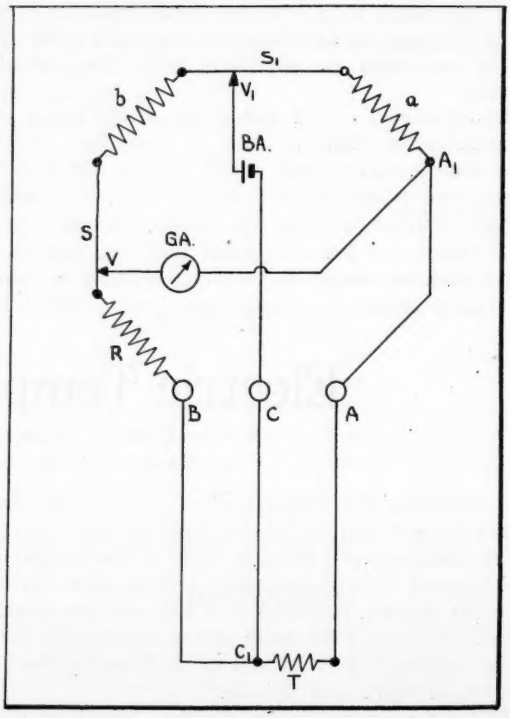


FIG. 7. THEORETICAL DIAGRAM OF RESISTANCE DETECTOR MEASURING EQUIPMENT

assuming the hot end temperature to be constant. To balance this decreased voltage the slider D is moved along its scale to a new point nearer G. In other words, the slider D is moved along its scale until it corresponds to the known temperature of the cold end and then the potentiometer is balanced by moving the slider G. The readings of G will then be direct.

The same results will be obtained if a slide wire upon which D bears is in parallel with the slide wire of G, as shown in Fig. 4.

Automatic Compensator

It should be noted that the effect of moving the contact D, Fig 4, is to vary the ratio of the resistance on the two sides of the point D in the secondary slide wire. In some recording and indicating instruments, an automatic compensator is employed. In the Leeds & Northrup Co. instruments, this automatic compensator varies the ratio on the two sides of the point D in the following manner:

Point D, Fig. 5, is mechanically fixed; on one side of D is the constant resistance coil M, on the other the nickel coil N. N is placed at or near the cold end of the thermocouple (or couples). Nickel has a high temperature coefficient and the electrical proportions of M and N are such that the resistance change of N, as it varies with the temperature of the cold end, has the same effect upon the

balancing voltage between D and G that the movement of the point D, Fig. 4, has in the hand-operated compensator.

Figure 6 shows a modification of Fig. 5 to meet the condition where the cold junction of the thermocouples is to be located at some point distant from the measuring instrument, as for instance when it is located on the frame of the generator. This connection is desirable when runs of over 100 feet are required.

Resistance Detector Measuring Equipment

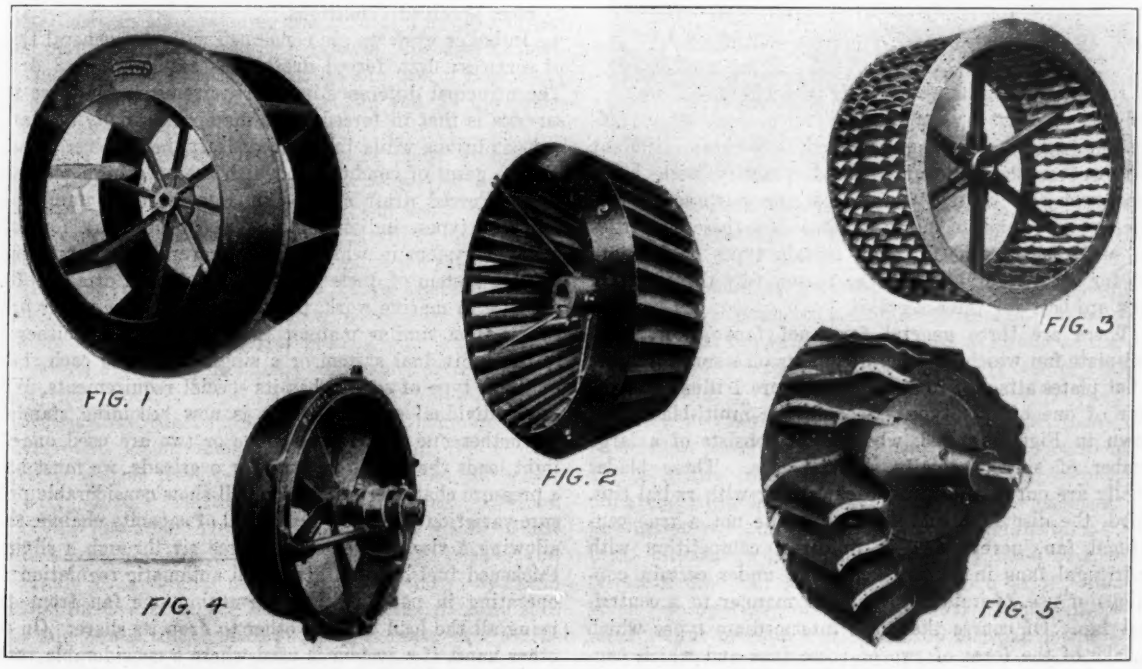
Figure 7 gives the theoretical diagram of the measuring circuit of this type of equipment. It will be seen that this diagram is essentially that of a double slide wire Wheatstone Bridge, in which all moving contacts are in the galvanometer or battery circuits where they cannot affect the accuracy of the measurement. The two slide wires are mechanically tied together, and are electrically so proportioned that at all points on the slide wire the resistance $A_1 V_1$ is equal to resistance VV_1, thus keeping the ratio arms of the bridge at unity. As the dial is rotated, however, the resistance VB varies, and since $VV_1 = A_1V_1$, the bridge will be balanced when $VC_1 = C_1A$; in other words, when the variable resistance in the arm VB equals the varying resistance in the detector coil T. By proper calibration of the slide wire S, which makes up the variable section of the resistance VB, this setting is read in terms of temperature at T, instead of in ohms.

AT, BC_1, and CC_1 are the leads from the coil to the bridge, and it will be seen that as $AT = BC_1$ in resistance, the length of the leads is without effect upon the accuracy. As these are leads of the same size copper wire in the same cable, this condition is bound to be met.

Centrifugal Fans and Their Characteristics

Part I. Principles of Centrifugal Fans, Types, and Service Requirements. By R. T. Livingston*

CENTRIFUGAL fans are used for supplying or moving air at or against small resistances. Due to the fact that they perform their work by reason of their rotation they are ideal machines for connection to electric motors or (in special forms) to steam turbines.



FIGS. 1 TO 5. DIFFERENT TYPES OF CENTRIFUGAL FANS

Fig. 1. Rotor of steel plate fan. Figs. 2 and 3. Two types of multi-blade fans. Fig. 4. An intermediate form of fan, a cross between the true steel plate fan and the multi-blade types. Fig. 5. A section of the rotor of a modern type of disc fan, showing the shape of the vanes.

Energy is imparted to the air by means of a number of vanes of varying shape and number, due to centrifugal force. The increase of pressure through the fan is obtained due to the difference in centrifugal force at the entrance to and exit from the vane, at the same time the air also possesses energy due to its velocity at exit (kinetic energy) and it is one of the functions of the casing to convert a part of this kinetic energy to pressure.

It may be said that there are two general types of fan services: First, where the function of the fan is mainly to move the air against small or no resistance; in this case, velocity is the important thing. Second, where the air must be moved or supplied against a quite definite resistance; here the quantity may be relatively small and the pressure relatively high. The extreme example of the former is the familiar desk fan or the "man cooler" in industrial work and of the second is the centrifugal compressor. The wide application of centrifugal fans, how-

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ever, is in an intermediate range where a large volume is required against a small resistance.

Air can possess energy in a number of forms. In our consideration, the most important are, first, that due to its pressure and second, that due to its velocity. The former is called static pressure and the latter is called velocity pressure. The sum of these two pressures is called total pressure or sometimes dynamic pressure. While we usually find that the pressures are spoken of, in the case of centrifugal fans, as so many inches of water, we must not forget that actually we should consider pressures in feet of fluid considered, in this case air. When computing velocity pressure, it will be found easier to compute it in terms of feet of air. Obviously, as the temperature and density change the number of feet of air equivalent to an inch of water will also change but under standard conditions this is very close to 70 ft.

To determine the equivalent feet of air when the head in inches of water is given the following formula may be used.

$$H = h \times (d \div 12\,W)$$

where H = head in feet of air
h = head in inches of water
d = density of water
W = weight of air in lb. per cu. ft.

At standard conditions of 70 deg. F. and 29.92 in. barometric pressure, d is equal to 62.31 and W equals 0.07495.

then $$\frac{d}{12\,W} = \frac{62.31}{12 \times 0.07495} = 69.95$$

and the above formula becomes, H = 69.95 h.

Fans are built in a number of forms for various different purposes. The change in form is to obtain different relations between the variation of quantity with head, horsepower and efficiency and it is the purpose of this article and the ones to follow, to show how these quantities vary with the type of fan, how certain types of fans are best for certain services and the reason why these certain types are best for these services.

There are three general forms of fans: First, the steel-plate fan which in general consists of a small number of flat plates attached to a spider. Figure 1 illustrates the rotor of one of this type. Second, the multi-blade fan, shown in Figs. 2 and 3, whose rotor consists of a large number of small, radially short, blades. These blades usually are curved, forward, backward or with radial tips. Third, the disc fan, Fig. 4 which, while not a true centrifugal fan, nevertheless is in direct competition with centrifugal fans in certain fields and under certain conditions of use, operates in a similar manner to a centrifugal fan. Of course there are intermediate types which partake of the form of two of these fans and which cannot be definitely placed in any of the classes. A good example of such an intermediate form is the modern high-speed-drive fan, with a considerable number of blades curved backward and extending a considerable distance radially, thus forming a connecting link between the true steel plate and the multi-blade fans. This type of fan is illustrated in Fig. 5.

As well as differing in mechanical construction, these fans differ widely in performance. The performance of a fan may be shown graphically in a number of ways but perhaps the best way is to plot curves of static pressure, total pressure, horsepower and efficiency against capacity. In order that one curve shall serve for a complete line of similar fans it is customary to plot all these quantities in percentages of the rated, or given, quantity. This can be done because all centrifugal machinery obeys certain laws of similarity, hence if at one point (called rated point) all quantities are known for a fan at one speed then this same point for any other speed can be computed.

Although the laws have been stated in a number of forms by numberless authorities, they will be repeated here. First, the total head varies directly as the square of the speed while at the same time capacity varies directly as the first power of the speed and the horsepower as the cube. Also for any given type of fan (all symmetrical) operating at a given tip speed and at a given point of the characteristic curve, the speed will vary inversely as the diameter while the quantity and horsepower will vary directly as the square.

There are two other points which are also quite important in the consideration of air machinery. The first is that at constant pressure and a constant point on the curve, that the quantity, horsepower and speed vary directly as the square root of the absolute temperature. Second at constant capacity and speed the horsepower and head vary directly as the density and also approximately inversely as the absolute temperature. These may be called "the laws of fan performance" and an understanding of them is absolutely necessary for any real use of characteristic curves and an ability intelligently to select fans to meet specified conditions.

In boiler work we are concerned with two general types of services: first, forced draft and second, induced draft. The principal difference in the requirements for these two services is that in forced draft the air is usually at standard conditions while in induced draft the fan has to handle the gases of combustion which are at a high temperature. Forced draft may be in any one of a number of different types, individual blower (or blowers) for each boiler, a system in which one (or several) blowers supply air to a system of ducts going to each boiler, or as is often the case in marine work, the fire room may be under pressure. In a similar manner induced draft may either be of the individual system or a single blower to each stack.

Each type of service has its special requirements. With any individual system—which is now becoming standard—whether one fan is used alone or two are used one for light loads the two to be used for overloads, we must have a pressure characteristic which will show considerable pressure variation without a great deal of capacity change, thus allowing a rise of pressure to force air through a slightly thickened fuel bed and giving an automatic regulation for operating in parallel, thus preventing one fan from carrying all the load and the other to drop its share. On the other hand, if a system is used where a considerable variation of quantity is required without much variation of pressure and where there is no operation in parallel a fan would be desired whose characteristic permitted wide capacity variation and at the same time little static pressure variation or, as one would say, a "flat characteristic."

Of course if an increase or decrease in both quantity and static pressure was desired simultaneously, this could only be obtained by a change in speed (except to a limited extent as will be seen in the case of the forward curved multi-blade fan). In the next section of this article the different types of characteristics given by the different types of fans will be discussed and the relative advantages of each will be pointed out.

District Steam Heating Proves Economical

SYSTEM USING HIGH PRESSURE STEAM IN THE ST. LOUIS BUSINESS DISTRICT SHOWS CONSIDERABLE SAVING OVER THE USE OF ISOLATED PLANTS. BY H. A. WOODWORTH

PRACTICALLY ALL central station underground steam heating systems were installed before the War, many of them, 20 to 30 yr. ago. On this account the closing down of the electric end of the power plant has caused the steam heating end to pass from exhaust to live steam. This condition has caused the "live steam business" to assume all the burdens of the investment and all operating expenses whereas the heating business was originally started as a by-product business. The ideal arrangement for central heating is the actual physical combination of electric and steam heating plants through the combination of the power and heating load.

By constructing for both steam and electric business, the plant can be built at less cost per unit than for either the electric or steam business alone. Given an equitable and adequate rate we have the ideal condition by combining the electric and heating loads, provided the heating load is of such a character as to combine with the electric load to advantage and that the investment in the distribution system is not prohibitive.

In New York, Chicago, Boston, Pittsburgh, Detroit, St. Louis, and Portland, we find that modern office and merchandise store buildings are users of district steam. One central heating plant is doing the work of a number of isolated plants that have been closed down. The district heating business is at a distinct advantage in that it may select the area in which it will supply steam and fix the prices which shall be charged.

With a high pressure central heating plant, we find the fundamental advantage is certainty of service and convenience. The customer knows he can have 24 hr. of service every day in the year and he is willing to pay more for this service than what he could make the same amount of steam for in his isolated plant. I have operated central heating plants for 16 yr. and have never seen a customer without service from a central heating plant; however, I have taken over many isolated plants which have failed to satisfy the owner.

Electric lines can be run at low cost as compared with underground steam mains; hence, we find the electric plant miles from the city on a river or railroad and where large coal storage facilities are available. The central steam plant, on the other hand, is found in the heart of the business section, using city water for steam, trucks or rail to handle coal, double deck boilers and large overhead bunkers for coal storage. While the electric company sells light and power to the office building it must have a central heating plant in order to heat the building and furnish hot water and high pressure steam for cooking and operating elevator and ice machinery, otherwise the isolated plant could not be shut down.

Thus, we find one power house with a single large stack over a battery of boilers furnishing steam that was formerly furnished by several hundred single plants with their individual chimneys and undeniably we have a cleaner city. The central heating plant is attractive, modern and economical in operation and under such conditions will produce steam in volume which may be sold at a profit.

Three important factors should be kept in mind in the design of an underground main distribution system, namely, low maintenance, low depreciation and low transmission loss. In general, construction is of two types, buried and tunnel. Usually the high cost of tunnel construction in addition to the piping and insulation costs makes it commercially prohibitive. The "easy access" feature of tunnels is not as good as a well-designed and carefully installed line with proper under-drainage. The pipe covering should be about 3 in. thick and of the best grade. The conduit of tile with air space is similar to that used in building wall construction.

FIG. 1. BUSINESS DISTRICT OF ST. LOUIS IS SUPPLIED WITH HIGH PRESSURE STEAM FROM A CENTRAL PLANT

Pipes should all be welded and no flanges should be used. I have conducted a number of tests on welded joints and find that the welded joint is just as strong as the pipe itself provided care is used by the expert welder in making the weld.

High pressure steam business as conducted today with an efficient power plant and where the underground mains are efficiently installed will show a greater income per dollar invested than any other public utility business. The production of high pressure steam is a manufacturing business. Steam can be made in large quantities at a predetermined cost and sold in amounts at a profit. Having given the necessity of a product and the certainty of a market it is necessary to determine to what extent a district heating plant will be profitable. The ultimate extent to which a district heating plant will be profitable depends upon:

1. The volume of business.
2. A properly constructed plant.
3. Efficient management.
4. The method of charging for steam supplied.

Figure 1 shows an aeroplane view of a group of buildings in St. Louis which are supplied with high pressure steam. The power plants are in the business district and deliver steam at 225 and 175 lb. Steam is conveyed through underground pipes through the streets to the vari-

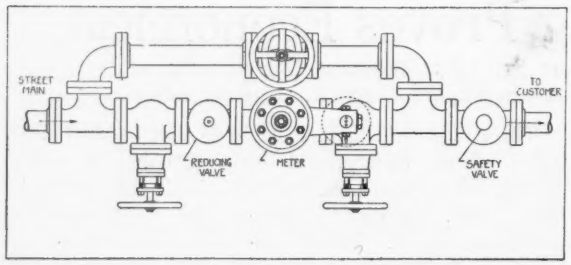


FIG. 2. METHOD USED FOR INSTALLING FLOW METERS

ous buildings which use the steam to operate engines, ice machines, steam elevator pumps, for cooking, heating hot water, pressing, dyeing, running printing presses and heating of the buildings. Steam is sold through St. John steam flow meters and also through condensation meters. The steam is measured by flow meters as it enters the premises after passing through a reducing valve that reduces the pressure from 175 lb. to the pressure desired by the customers. The flow meter is installed as shown in Fig. 2.

In order to insure dependable service it was found necessary to devise a long distance signal system that would enable the chief engineer of the plant to know when additional steam-driven equipment was being placed in operation, the location, size of the unit and the period of time the unit would be used in order that he could put sufficient additional boilers into immediate operation to maintain a satisfactory steam pressure all along the line.

This method is of inestimable value and should interest all heating companies that operate high pressure central

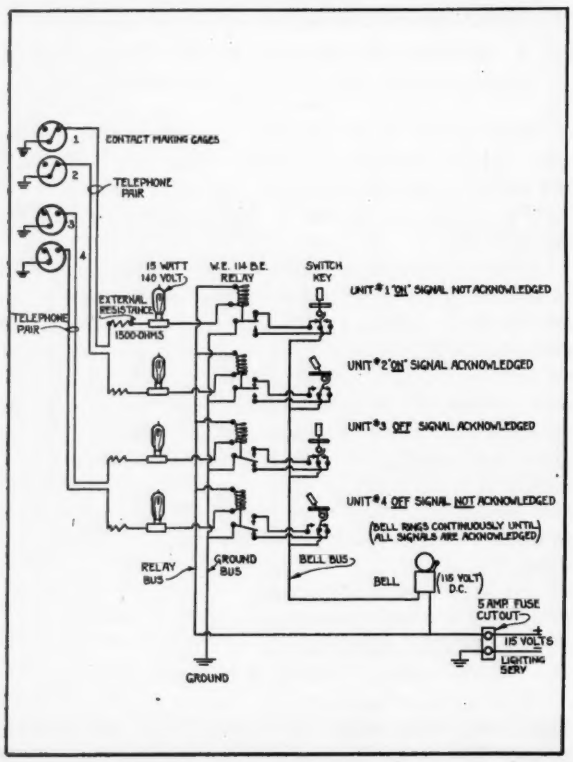


FIG. 3. SIGNAL SYSTEM FOR INDICATING OPERATION OF ISOLATED STEAM EQUIPMENT

heating systems. Such companies can well afford to install such a load indicating device.

During the cold weather the system is not relied upon as much as during the spring and autumn months, as the load is fairly constant from day to day, that is, the high and low points of the load occur about the same time every day except Sunday when the load is rather light.

During the months of September, October, November, March, April and May, however, an entirely different condition arises. It is during these six months that a considerable saving can be effected through the medium of this signal system, enabling the engineer to predetermine the load within certain limits. During the milder months a building may take steam for only 2 hr. in the morning and about the same length of time in the afternoon.

At this time of the year a number of the larger buildings may shut off their steam at the same time and if an indicating device of some kind is in operation, the fires can be checked immediately whereas without an indicator it would be necessary to wait until the pressure started to increase and the boilers to pop off. The reverse condition applies when a number of the buildings turn on at the same time, that is, the fires can be pushed a little harder or another boiler can be placed in service before the actual increase in load is noticed at the plant.

Amount of steam taken and the hours of services vary for each kind or type of building. Careful observation will show that heavy loads arise on mild days that follow a colder period due to the opening of doors and windows instead of closing the radiator valves.

It was this idea that caused the steam heating department of the company I am connected with to make an investigation of the various long distance pressure recording and indicating devices that are on the market today. The well-known long distance recorders and transmitters was found impracticable because of the prohibitive cost of installing the necessary wires underground. The recorder being limited to a certain resistance per wire made it impossible to use the local telephone company's lines in connecting the instruments. The next best thing to be done was to develop some kind of home-made device that could be operated over the telephone lines. When a new steam distribution system is under construction, however, signal wires can be placed along with the mains, thereby making it practical to use a standard long-distance recorder.

This home-made load indicator, shown in Fig. 3, consists of an arrangement whereby the turning off and on of any one of a large number of buildings is made known to the engineer in a rather forceful manner, that is, by the ringing of a bell and the lighting of the light for that particular building.

Many of the large buildings on this heating system have hydraulic elevators whose power is furnished by steam pumps during the time when heat is required on the buildings and by electric pumps when it is not. The exhaust steam from these pumps furnishes steam necessary for heating, therefore, if the engineer knows what pumps are in operation his problem is solved.

In order that this might be done contact-making pressure gages were placed in the line between the throttle valves and the high pressure cylinders. Just as soon as any one of the pumps is turned on the pressure builds up causing the contacts to close, lighting a light and ringing

a bell in the boiler room. The bell is a large signal gong that can be heard easily at all times in all parts of the boiler room. In order to stop the ringing of this bell it is necessary for the engineer to go to the signal panel and throw the switch for this building to the running or "on" position. He can tell which building caused the bell to start ringing because the signal light will show the building "on" and the switch will be in the "off" position.

When a pump is shut down its light will go out and the bell will begin to ring. In this case the light indicates that the pump is "off" and the switch is "on." Then to stop the bell's ringing the switch must be moved to the "off" position.

In cases where the pressure gages are used to indicate whether the pressure at some important point is above or below some critical pressure the following scheme is used. The lamp is burning when the pressure is at or above that point and is out whenever the pressure falls below that point.

There are eleven panels which indicate the operation of the elevator pumps and two which indicate pressure. One of the pressure panels operates when the pressure at the throttle valve of an important stand-by engine generator drops below 100 lb. gage. Under special agreement the heating company has contracted to furnish 100 lb. pressure at all times, therefore this unit is of great importance. The second pressure gage is on a service line to one of the large newspapers where it is necessary to maintain a high pressure in order that the paper might go to press at certain times each day. The steam being used in a drying process, the same high temperature at all times is essential.

In a city like St. Louis the volume of business requires approximately 1000 hp. per city block, all of which saves the hauling of about 3000 T. of coal to these city blocks if the block is heated by district steam. This saves about 600 T. of ash removal or $6000 for coal and ash handling per business block per year. Think of the saving due to cleanliness, reduction of fire hazards, and space saved due to the absence of boilers by using district steam. Coal is bought in the fall and paid for within 30 days—but with district steam, heat bills are rendered upon completion of each 30-day period. You pay for it as you use it and pay only for what you use.

All of the steam used is metered by accurate metering methods. Fundamentally any product which can be weighed or measured should not be sold on a flat rate. As with other investments the heating business is expected to pay adequate returns on the investment after deducting operating costs and fixed charges. Rates for heating should be fixed with this fact clearly in mind.

Accurate metering must be assured the customer, hence, it is necessary to test the meters periodically so that the customers will be satisfied. A condensation meter testing plant can be installed for $100. A flow meter test plant will cost about $3000.

Any utility company selling high pressure steam is frequently called upon to explain what appears to the customer to be an abnormal bill. If the customer is not sure that he has used the amount of steam charged, because of increased business or some other sufficient reason, he will promptly say that the meter was mis-read or that it is fast. If the meter has been mis-read, the matter can easily be

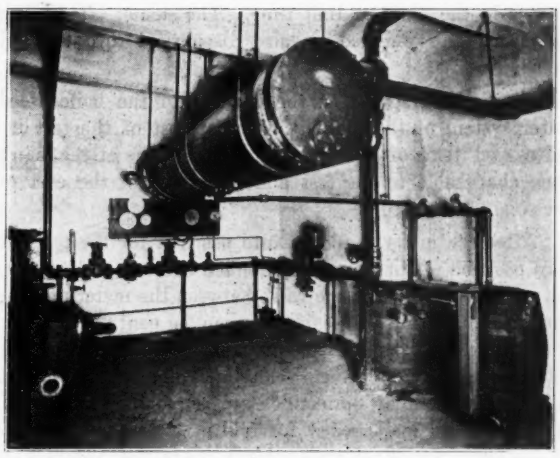


FIG. 4. FLOW METER TESTING APPARATUS

solved by having another reading made; however, if the customer insists that the meter is wrong, it is necessary to remove the meter and take it to the shop for a test.

Methods of testing depend entirely upon the type of meter. There are two general types of meters used in the measurement of steam for the heating of buildings, one being a condensate and the other a flow meter. The testing of condensate meters is an exceedingly simple process. As the meter measures water, the meter can be tested by running water through it and weighing the discharge. With the high pressure flow meter, we have a different problem because the discharge from the meter is steam which must be condensed before any check can be obtained regarding the accuracy of the meter. The apparatus necessary for testing such meters must be so designed as to be able to maintain the normal working conditions of the meter throughout the test. To do this the pressure must be regulated to meet the operating pressure of the meter and the quantity of steam flowing must be controlled so that the meter can be checked at different loads.

Testing apparatus that we use in checking the accuracy of St. John meters consists of two traps, four indicating thermometers, one recording thermometer, one recording pressure gage, a reducing valve, meter flanges, one 500-sq. ft. condenser and scales for weighing condensate, as shown in Fig. 4. The arrangement of the apparatus is shown in Fig. 5.

Cooling water is taken from the city water supply line of the plant after it passes through the condenser. It is discharged into the hot well or sewer, depending upon con-

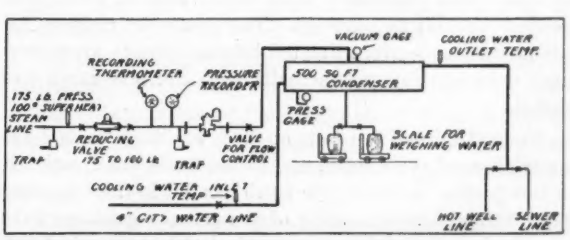


FIG. 5. DIAGRAMMATICAL ARRANGEMENT OF APPARATUS USED FOR TESTING FLOW METERS

ditions in the plant at that time. The steam, after being condensed and weighed, is also discharged into the hot well.

By discharging all of the water into the boiler feed water system of the plant, the actual cost of the test involves two items of expense, namely, the value of the man's time chargeable to the test and a portion of the cost of the steam consumed.

After the meter is placed into position for the test the zero position of the pencil mechanism can be checked. By varying the opening of the valve between the meter and the condenser the rate of steam flow can be controlled. The condensate is first turned into one of the two barrels mounted upon the platform scales and then into the other. After the weight of the condensate is recorded the barrel is drained and made ready for refilling. By making tests at different pressures and various loads the accuracy is determined for each of the test conditions. The amount of steam as recorded by the meter is obtained by multiplying the meter constant as furnished by the manufacturer by the mean ordinate of the chart, which is found by the use of a planimeter.

If it is desirable to know the effect of the meter upon the temperature and pressure of the steam it would be necessary to have a gage and a thermometer placed between the meter and the valve which controls the flow. With the aid of these instruments we would be enabled to determine the effect of throttling upon the temperature and pressure of the steam.

If the results of a test show that a meter is consistently high or low, the correction can be applied in either of two ways, one being to apply a correction factor to the steam flow as shown by a correction chart and the other being to change the constant of the meter.

This testing plant was designed for testing St. John meters on our steam distribution system, but can and has been used for testing other types of flow meters.

My experience with isolated plants in which exhaust steam is being wasted to the atmosphere after its utilization for building heating is that the cost is at a maximum as compared with an electrically equipped building that uses high pressure steam from a district steam plant for its heating and process work. This has led to the conclusion that electrified machinery automatically controlled to replace steam-driven equipment in building power plants eliminates fuel wastage, requires less labor and simplifies operation and greatly reduces the cost of upkeep and repair. Actual trial over a long period of years has proven the advantages of district steam and has disproved the economies mistakenly claimed for the older system of complicated steam machinery from which exhaust steam was released for heating purposes. The economies claimed for this method were overestimated because nobody knew how much exhaust steam was actually used and how much was wasted.

Not until I had run tests on office buildings to find out the relation of the electric and steam loads was I satisfied on this point. Knowing the truth has led to the foregoing recommendations as a study of the actual conditions have proved conclusively that purchased electric power and district steam is the most dependable, economical and efficient combination.

Steam Generation with North Dakota Lignite

IMPRESSIONS, somewhat prevalent throughout the northwest, that North Dakota lignite cannot be burned successfully under steam boilers are falsely founded and are the result of the general use of poorly suited grates and incorrectly designed furnaces and boiler settings. This conclusion is reached by George B. Wharen in an article on this subject which appeared in the June issue of The Quarterly Journal of the University of North Dakota.

It is further stated that with established values of combined boiler and furnace efficiencies of 58 to 63 per cent by the year, with raw North Dakota lignite averaging 33 per cent moisture and 6800 B.t.u. per lb., plant owners and engineers have good assurance that this lignite can be burned satisfactorily.

Coal from this region is relatively high in moisture and low in ash content while the combustible matters are about equally divided between the fixed carbon and volatile matter; and the sulphur content is usually small. The lignites are also high in oxygen. The heating value is relatively low when calculated on the wet basis, although when moisture free, or even air dried the lignites have relatively good B.t.u. values.

This coal upon being exposed to heat does not coke but disintegrates and crumbles to a fine dust which, when burned on a grate, offers a high resistance to air flow and renders uniform fuel bed and air distribution difficult. Slicing of the fuel bed is prohibitive. Rocking grates afford better opportunity to work the fire than do ordinary stationary grates.

Two chief losses in the furnace when burning this coal are: First, the loss due to evaporating the moisture, and second, the loss due to the combustible matter dropping through the common types of grates, caused by the disintegration of the lignite while burning. Therefore the maximum of economy in the use of lignite for steam generation is to be had only by pre-drying or low temperature carbonization and pulverizing the dried lignite or carbonized residue and burning the dust in suspension without the use of grates.

Sufficient progress has been made in drying, pulverizing and burning in suspension the lignite to warrant development of this method. With this system, dried lignite, mine run or screenings, with moisture content up to 15 per cent, or carbonized lignite residue, may be used with probable efficiencies of 73 to 78 per cent by the year. The commercial success for the small plants operating at present in the lignite territory lies in the ability to furnish the equipment so as to embody the following essentials: low initial cost, small maintenance charges, reliability in service, fine pulverization with a minimum of power demand and large coal grinding capacity with small floor space. For small plants the unit system is most essential.

Waste heat driers have been in operation wherein the moisture content has been reduced from 35 per cent to 10 and 15 per cent. This coal apparently does not need to be pulverized to as fine a degree as do the bituminous coals. Good combustion and flame conditions are secured with about 40 per cent through a 200-mesh and 70 per cent through a 100-mesh screen.

Choice of Prime Movers for Ice Plants

YOUR ARTICLE, "Choice of Prime Movers for Ice Plants," which appeared on pages 867-8 of the August 15 issue, is scarcely fair to the modern oil engine driven ice plant. We do not refer to the figures given for the original investment of the complete plant but to the operating cost figures.

In this article the oil engine plant is charged with:

1 Chief engineer, $275 per month	$3300	per year
2 Watch engineers, $175 per month	4200	per year
2 Extra men, $36 per week	3744	per year
3 Ice pullers, $30 per week	4680	per year

Why is it necessary to charge in two extra men for an oil engine-driven plant when none are charged in for the electric-driven or steam-driven plants? Surely an installation consisting of three modern oil engines does not require two extra men to look after the engines. The chief engineer and watch engineers should be all that are necessary to look after this plant. The elimination of the two extra men will reduce the estimated operating cost by $3744 a year.

In that portion of the article which refers to the fuel oil cost for operating this plant the estimate is given as "2.6 engine b.hp. per ton of ice, including storage, 7 gal. of fuel oil per ton, at $0.05 per gal., or a total cost for fuel oil per (11 mo. operation, or 32,000 T. per yr.) of $11,160."

Modern high economy oil engines require approximately 0.45 lb. of fuel oil per b.hp. hr. If 2.6 engine b.hp. are required per ton of ice, then using this correct fuel oil consumption, the fuel oil cost per ton will be.

$$2.6 \times 24 \times 0.45 \div 7.5 = 3.75 \text{ gal.}$$

At a cost of $0.05 per gal., the yearly cost for fuel oil to operate this plant, under the conditions outlined, will be $6000—or $5160 less than that given in the article.

It is further stated in the article that "—the engine lubricating oil required is 1 qt. per 100 hp., which equals 0.75 gal. per T. of ice, which at a cost of 50 cents per gal. totals $2800 per yr."

This is altogether too high, for in a modern oil engine, such as mentioned above, the lubricating oil consumption will be from 1 qt. per 500 rated hp.-hr. to 1 qt. per 1000 rated hp.-hr. On the basis of 1 qt. per 500 rated hp.-hr. the oil consumption will be one-fifth that specified in the article. The cost, therefore, will be one-fifth of $2800 or $560. This results in a saving of $2240.

There is another item which I would like to question and that is the statement, "maintenance of machinery 5 per cent on $123,500." It is scarcely fair to charge up such a maintenance charge for the oil engine plant. This is especially true when compared with the maintenance on the steam plant of 3 per cent and that on the electric-driven plant of 3 per cent. It is not likely that the oil engine-driven plant will require any greater maintenance charge than the steam-driven plant with boilers, water heaters and other numerous accessories. With a maintenance charge of 3 per cent for the oil engine plant this will equal $3705 per year, instead of the $6175 quoted in the estimate.

Depreciation on machinery charged against the oil engine plant is 9 per cent. There is no reason why more than 6 per cent should be charged. This is the figure used for the electric-driven plant which included the same ice-making machinery as is used in the oil engine-driven plant.

If 6 per cent is charged on the oil engine plant it will be $7410 instead of the $11,115 shown in the article.

Total operating cost, if figured in this manner would, therefore, be $17,319 less than that quoted in the article. This will reduce the original total figure of $81,188 to a total of $63,869. This divided by 32,000 T. is $1.995 per T. This figure is considerably less than that given in the article for the cost per ton with electric current at 1.5c per kw.-hr.

These figures do not represent the best possible performance of a high economy oil engine. The fuel and lubricating oil economies are such as can be secured in a number of similarly developed machines. A further saving favoring the oil engine plant could be shown if direct-connected oil engine ammonia compressors were used instead of belt-driven units, as figured upon in the original estimate. The engine brake horsepower required per ton of ice in this case would be decreased at least 3 per cent, which is a conservative figure for belt losses.

New York, N. Y. L. H. GEYER.

Faulty Drier Operation

HAVING SEEN no comments or suggestions on M. W. C.'s contribution in the Feb. 15 issue, page 253: "Faulty Drier Operation," I wish to quote the following:

M. W. C. says: "Occasionally the cotton did not dry as it should and when this happened, the operator would open a 1-in. valve from receiver to atmosphere with the result that the drying effect was increased.

He does not state whether or not each coil was trapped individually but in any event, if opening the 1-in. valve to atmosphere increased the drying effect, which means the circulation of steam in the coils was increased, it stands to reason that something was obstructing the flow of steam through the coils.

This could happen if the receiver became full of water. If the 1¼-in. discharge M. W. C. speaks of, emptied into an open heater where cold make-up water was used there might be times when the level of water in the heater would

be above the end of 1¼-in. discharge from the receiver. This of course would cause water to back up into the receiver and eventually fill it, which would slow up circulation in the coils with a consequent lowered heating efficiency.

Then, again, the heater pump might not be traveling fast enough. Still another cause would be the varying wetness of the cotton, which would require an increase in the drying time.

I once worked in a cotton mill which operated two slashers with four or five drums each.

The pressure on these drums was kept at 12 to 15 lb. by a reducing valve reducing from 85 lb. boiler pressure. The condensate was trapped to a vented receiver tank.

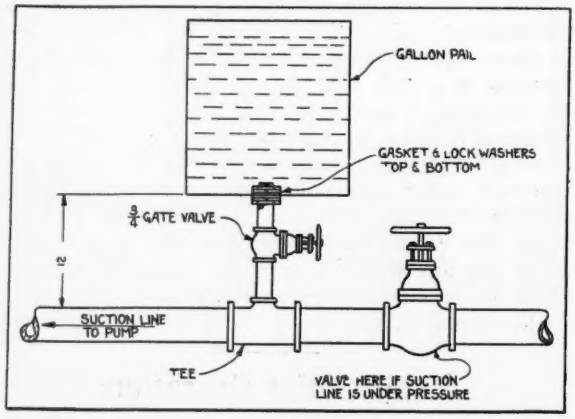
This same difficulty in drying that M. W. C. speaks of, was experienced with the result that the drips were more or less frequently opened to the atmosphere, especially when the "warps" came on with an exceptionally heavy coat of starch.

The efficiency of a coil is at its best when the circulation of the steam in the coils is constant. This does away with troublesome air pockets and materially assists in carrying away condensate.

Worcester, Mass. LEROY BLAKE.

Compound Feeder on Pump Suction

THERE IS one criticism I would like to make on H. A. Jahnke's letter in the Sept. 15 issue on page 968, "Soda Ash as a Boiler Compound." He does not state what kind of valves he uses in his feed pumps.



SIMPLE ARRANGEMENT FOR FEEDING BOILER COMPOUND

To the uninitiated: In feeding soda ash, care must be used in feeding through the pumps that the pump is not allowed to stop pumping until the soda ash has all been pumped into the boiler and sufficient time allowed so that the pump will be thoroughly rinsed with the clean feed water. Otherwise the strong caustic would soon ruin any rubber valves.

In a plant where I was employed we had a pump fitted up with brass valves and used exclusively for this purpose.

We were at one time rather heavily scaled at the rear of the tubes and the back tube sheet. To clean this unit we mixed 50 lb. of soda ash with 10 gal. of kerosene. This was poured into the boiler and a slow fire, just enough to keep the water boiling, was kept up for two days, with top manhole cover off.

This makes an effective "dose" for a starter and should be repeated if necessary. This mixture is effective in cutting grease and oil out of a boiler.

By following up each week with from 5 to 10 lb. soda ash dissolved and pumped into the boiler, scale can be kept at a minimum.

We used a feeder, which was a home-made affair as shown in the accompanying sketch.

With the valve sheet the solution was poured into pail or can, the pump started slowly and the ¾-in. gate valve cracked open.

If the suction line is under pressure, the valve on suction line should be shut off temporarily and pump will soon lower the pressure and pull the solution out of the feeder.

Worcester, Mass. LEROY BLAKE.

Location of Air Receivers

IN THE Sept. 15 issue of Power Plant Engineering there is a note which advises that "air receivers, or tanks, should be placed as close to the compressor as possible so that the discharge pipe may be kept short." This injunction, having no practical support, has been the cause of loss of life—several lives to my personal knowledge.

Evidently the purpose of placing the receiver close to the compressor is to reduce the loss from friction in the discharge pipe. Often the location of the receiver is in the direction of travel of the air on its way to the tools or other apparatus, hence placing it close to the compressor accomplishes nothing worth while; in fact, where rapid cooling is desirable, it can be better effected per unit of exposed surface in the small discharge pipe than in the large receiver.

Theoretically a 12 by 10-in. compressor running 200 r.p.m. with a volumetric efficiency of, say, 76 per cent will deliver about 200 cu. ft. of free air per minute. This size compressor has a 4-in. discharge pipe. At 80 lb. gage, the loss of pressure from friction in 100 ft. of the pipe is about 0.013 lb. per sq. in. Trifling indeed! Pressure-gages cannot be read to that degree of accuracy.

In view of the foregoing and my experience with numbers of compressor installations, I would regard the air-receiver as an explosive hazard and be governed accordingly. Never place it indoors if it can be avoided!

It must not be thought that the air-receiver is inherently dangerous. Far from it! The explosions of receivers due to operating pressure are extremely rare; in fact, I do not recall ever hearing of one—the danger lies in careless or mistaken use of lubricating oil.

It would be a great mistake to refrain from the use of so wonderful a convenience as is sometimes compressed-air because of possible danger but it is well to take every precaution insuring safety. Locating the receiver from consideration of the friction loss in piping is a mistake, as that is the least important of the several factors involved.

Kansas City, Mo. C. O. SANDSTROM.

Money from Ashes

I WAS greatly interested in the article on the reclamation of coal from furnace refuse, by S. H. Bunnell, which appeared on page 964 of the September 15 issue although I believe that his estimate of 40 to 50 per cent unburned

combustible in the refuse from all but a few furnaces is a bit exaggerated.

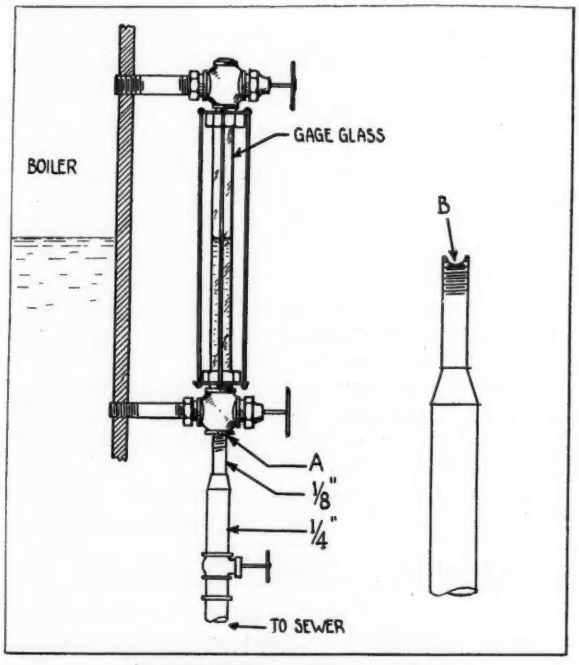
On several occasions I have obtained permission from officials of institutions to have ash dumps sifted and picked. In two cases the dumps were the accumulated ashes from 3500 T. of steam coal which had been burned in steam boiler furnaces having ordinary shaking grates, fired by hand. There was an unlimited amount of free laborers to do the sifting and picking. Rotary hand operated sifters were used, the mesh in the screens being ⅜ in.

After most of the clinker and slate had been removed, about 100 T. of fairly good coke remained. Had the laborers been paid, the cost would have been almost as great as the worth of the coke saved.

Toronto, Ont. JAMES E. NOBLE.

Cause of Rust Matter in Gage Glass

IN THE gage glass of a new 72-in. by 18-ft. return tubular boiler there had appeared a brown discoloration from the time the boiler was placed in operation about 9 mo. ago. It was necessary to blow out the glass quite frequently during the day's run. The coloring showed up much more after the boiler had been idle over night and Sundays.



RUSTED NIPPLE CAUSES DISCOLORATION IN THE GAGE GLASS

At first it was thought that oil or other foreign matter from the heating system, which was new, found its way into the boiler with the return water. There had always been a little leak at the lower gage glass valve at the blowoff connection as shown at A in the accompanying sketch. The nipple that screws into the gage valve is ⅛-in. black pipe, then the pipe is increased to ¼-in. up to the sewer connection. A short time ago it was necessary to disconnect the blowoff pipe from the sewer to the gage valve and when the ⅛-in. nipple was turned out it was found that the threads were nearly eaten away as shown at B, this was due to corrosion, which in turn was due to the leak at the joint. When I noticed the nipple, I came to the conclusion that the cause of the brown coloring matter in the gage glass was found, as I was under the impression that the corrosion of the nipple had caused rust in the water which looked like oil in the gage glass and I decided to use brass pipe in place of black. As the threads in the gage valve were worn badly, I enlarged the opening from ⅛ in. to ¼ in., then used a ¼-in. pipe from the valve to sewer.

After this there was no more brown coloring matter in the glass, showing that the leaky nipple had been the cause of it.

Milwaukee, Wis. H. A. JAHNKE.

Engineering vs. Business Diplomacy

MUCH HAS been said to the present day practical engineer concerning the technical side of his job, economy and efficiency, and how they can be obtained by the correct use of boiler and engine room equipment.

Many engineers often wonder why it is that one man is more successful than another of apparently equal engineering ability and what the other fellow has done to make good. The answer lies in his superior business ability.

Mr. Engineer, did you ever consider that you are, in a sense, in partnership with the president of your concern and that it is your duty as such, not only to keep the plant in operation but also to keep down the cost of operation, to run the plant as if it were your own? When you go in to talk to your employer, give him your report in a businesslike manner, tell him on a dollars and cents basis what you are doing. Do not criticize his plant unless you can put it on a constructive basis and do not talk in technical terms because more often than not you will not be understood.

Get acquainted with your employer on a business basis, not so much on an engineering basis. You will find that all the things which go to make up a first class plant will be at your disposal once you satisfy this man that you are not only a good engineer but a business man as well.

The engineer of today is one of the most valuable men around a manufacturing plant; he handles hundreds of thousands of dollars annually, in coal, water, current, machinery purchase, repair and maintenance but his engineering ability, although it may be pronounced, must be governed by a certain business success and tact, if he is to succeed.

Milwaukee, Wis. L. A. CORWIN.

CLAIMING THAT motorists are becoming contemptuous of the standardized stop, look and listen signs at rail crossings, a correspondent of the Michigan Public Utility Information bureau suggests that crossing warnings be "jazzed up" a bit to attract better attention. Here is what he suggests:

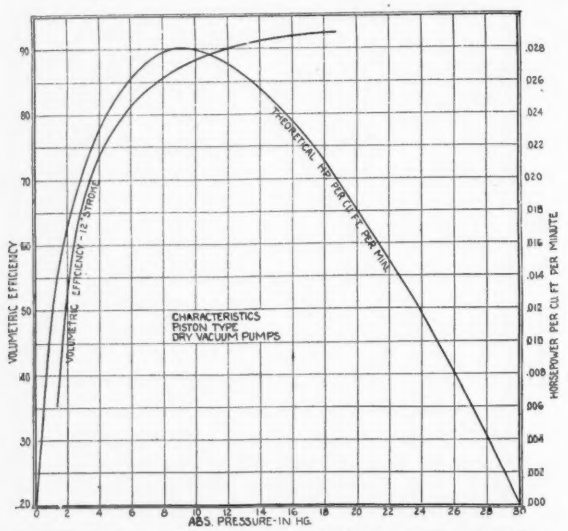
Come ahead. You're unimportant.
Try our engines. They satisfy.
Don't stop. Nobody will miss you.
Take a chance. A train can hit you only once.
Thousands get by safely. You should worry.
It's all right. There's a doctor around the corner.

QUESTIONS AND ANSWERS

Vacuum Pump Design

UNDER the caption "Vacuum Pump Design," on page 1020 of the Oct. 1 issue, G. L. asks concerning the operation of his vacuum cleaner pump.

Fundamentally, the cleaning effect incident to the operation of the vacuum cleaner depends upon the amount of air handled and the velocity with which it comes in contact with particles of dust, to be removed. There is, for



THEORETICAL POWER REQUIREMENTS AND TYPICAL VOLUMETRIC EFFICIENCY CURVES FOR VACUUM PUMPS

all ordinary purposes, a definite maximum velocity attainable where air expands from, say, atmospheric pressure to the vacuum obtaining on the suction side of your pump. This maximum value occurs when the pressure in the vacuum chamber is approximately half of the atmospheric pressure, or say, about 7 lb. per sq. in. absolute.

For any decrease below 7 lb. in the vacuum chamber, there will be no increase in velocity or in the amount of air handled. Consequently there is no advantage in operating at a 28.5 in. vacuum. The same results could be obtained with a vacuum as low as 16 in.

Operating at 254 r.p.m., the pump will handle $0.7854 \times 9^2 \times 21 \times 2 \times 254 \times 0.85 \div 1728 = 334$ cu. ft. of air per min. measured at 28.5 in. of vacuum. This assumes that the pump makes two working strokes per revolution and that the volumetric efficiency is 85 per cent. This is a purely arbitrary figure; actually the volumetric efficiency varies considerably with the vacuum carried. If this air is compressed adiabatically, it may be found from the laws of Charles and Boyle, $p_1V_1^n = p_2V_2^n$, that the volume at atmospheric pressure will be 33.9 cu. ft. per min.

If the pump is to handle air at 24 in. vacuum, or say, 3 lb. per sq. in. absolute pressure, the volumetric displacement will have to be about 124 cu. ft. per min., as also determined from Boyle's and Charles' laws. In a similar manner, it will be found that handling air at 16-in. vacuum or 7 lb. per sq. in. absolute pressure, the displacement will have to be only about 68 cu. ft. per min.

Symbols used in these two laws are p_1 the initial, and p_2 the final pressure of the air in lb. per sq. ft. absolute, V_1 and V_2 the respective volumes of a given weight of air at pressures p_1 and p_2, n is the ratio of the specific heat of air at constant volume to that at constant pressure, and is equal to 1.4, a constant.

If it requires a speed of 254 r.p.m. to handle a given weight of air at 28.5 in. vacuum, then to handle this same weight at 24 in. will require 95 r.p.m. and at 16 in. vacuum, 52 r.p.m.

Theoretical power requirements to compress air adiabatically may be found from the accompanying chart or from the equation:

$$W = \frac{144\, n\, p_1\, V_1}{n-1}\left[1 - \left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}}\right]$$

where

W is the work in ft. lb. required to compress the volume V,
n is the constant 1.4
p_1 is the initial pressure in lb. per sq. in.
V_1 the initial volume in cu. ft.
p_2 the final pressure.

If the work, as found by this equation, represents that required to compress the given amount of air in 1 min., then the horsepower requirements may be found by dividing this figure by 33,000.

Theoretical power requirements amount to 5.1 hp. at 28.5 in., 3.28 hp. at 24 in. and only 1.73 hp. at 16 in.

Steel Stack Rusts Through in Four Years

WE ARE operating a 150-hp. horizontal return tubular boiler carrying between 140 and 150 lb. pressure through the day. At night we run on banked fires and the boiler and stack cool down considerably. In four years' time we have rusted out a 10-gage steel stack, 57 ft. high, the rust apparently starting from the inside. We have had a new stack installed and we find that rust is starting inside this stack as well.

During the first 24 hr. of operation with the new stack, a peculiar gummy material collected on the inside of the stack and ran down through the seams to the outside where it dried out. This deposit shows an acid reaction and resembles burned sugar in appearance and odor.

What is the source of this deposit? Does it have a deteriorating effect on the steel? How can it be prevented?

C. M. A.

Critical Speed of a Turbine

WHAT IS meant by critical speed of a turbine, what causes it and how may it be found? L. B.

A. In a rotating shaft or, specifically, in a turbine rotor the center of gravity never lies on the mechanical axis of rotation. In the case of a horizontal shaft there is a deflection downward due to the weight of the shaft itself and the turbine disks which causes the center of gravity to lie below the true axis of rotation.

When the shaft is turned, it remains bent downward but as the speed is increased, the centrifugal force is increased until a state of equilibrium between centrifugal force and gravity is reached at what is known as the critical speed or, more properly, the first critical speed, for there are several. At this speed the centrifugal force is just sufficient to counteract the force causing the downward deflection and the shaft then rotates in a bowed form.

At the critical speed the maximum vibration of the shaft and consequently of its supports occurs and for this reason its determination is of great importance in design.

Above the critical speed the center of gravity revolves inside the bow of the shaft, the tendency being to cause the shaft to revolve about its own gravity axis and not about the mechanical axis.

There is a critical speed even when the workmanship on the shaft is perfect, that is, when the center of gravity lies on the geometrical center line in a shaft free from stress. This speed may be found mathematically as a constant divided by the square root of the static deflection. This constant depends on how the shaft is loaded and how supported and varies from about 124 to 245. The value ordinarily used is 187.7. In general, it applies where the load is considered as concentrated and where the ends are either supported or fixed.

For a shaft, supported at the ends and carrying a concentrated load at the center, the critical speed is

$$N = 187.7 \div \sqrt{d}$$

$$= 1{,}550{,}000\ D^2 \div \sqrt{W l^3}$$

where D is the shaft diameter, W is the concentrated load and, l, the length of the shaft between supports. The static deflection

$$d = W l^3 \div 48\ EI$$

where E is the modulus of elasticity which may be taken as 29,000,000, and I is the moment of inertia.

For a shaft carrying a uniformly distributed load and supported at the ends,

$$N = 2{,}232{,}510\ D^2 \div \sqrt{W l^3}$$

For a similar shaft, fixed at the ends,

$$N = 4{,}979{,}250\ D^2 \div \sqrt{W l^3}$$

Values given for N are for the first critical speed at which the amplitude of vibration is a maximum. There are, however, others of less importance. These others occur at higher speeds where the frequency of vibration is greater and amplitude smaller.

Methods used by turbine manufacturers for obtaining rotor balance have been developed to a point where extremely accurate balance may be secured. One manufacturer mounts the rotor to be tested on bearings carried on an inverted pendulum held in a vertical position by opposing springs. The rotor is speeded up above the speed of resonance by an electric motor and magnetic clutch arrangement; the clutch is then disengaged and the rotor allowed to coast down in speed through resonance where the amplitude of vibration is observed. Following this the clutch is reengaged; the current in the motor reversed and the rotor is rapidly brought to rest for adjustment of balance.

Ordinarily, in high-speed machines the elements of the rotor are balanced separately before being assembled on the shaft so as to eliminate as far as possible local couples that result in complex bending stresses.

Large turbines are usually designed to operate at a point well below the critical range. Smaller turbines are sometimes so constructed that the critical speed is below the normal operating speed. In starting up such a unit, great care should be exercised to pass through the critical speed as quickly as possible.

Low Boiler Capacity

IN THE plant where I am employed, we just installed a new 72-in. by 18-ft. fire-tube boiler. Ever since its installation this boiler would not deliver over 50 hp. The boiler is set 5 ft. from the gates which are 5 ft. long and have half-inch air spaces. The boiler is 18 in. from the back wall and 20 in. from boiler front. When this boiler is run for 10 hr., it takes two to three days for the brick to cool off before you can place your hand on it. When the other boiler is off the line I cannot keep steam at all.

I have looked for air leaks all over but could find none. The boiler is clean inside and tubes are cleaned twice a week. The other boiler burns 2½ T. of coal on a 10-hr. run and will furnish all the steam needed. This boiler I am writing about burns a little more than 3 T. in 10 hr. and will not make steam enough to run half of the shop. This new boiler is 25 hp. larger than the old one, which is 125 hp. What could be the cause of this low capacity? J. H.

A. From the information contained with your question, it is inferred that your lack of boiler capacity is due to lack of draft, which may in turn be due to any one of several causes.

In the first place, your grate may be too small or it may be so small that you find it necessary to carry a thick fire, which, of course, increases considerably the draft through the setting. In this size boiler the grate should not be less than about 30 sq. ft. in area. On the other hand, the opening over the bridge wall may be small enough to cause an appreciable loss in draft.

Ordinarily, for use with bituminous coal, the area between the bridge wall and the boiler shell should amount to about 25 per cent of the grate area. Other factors that may have some bearing on the subject are the capacity of your chimney and the arrangement of the breeching connections and the location and control of the damper.

As a rough approximation, we should say that you should have a stack about 110 ft. high by at least 33 in. in diameter to serve the 150-hp. boiler. It may be that your uptake dampers do not fit tightly in the uptake connection, therefore, if the two boilers are operated on a single stack, one of them may be hogging all the load.

It would be a comparatively simple matter to check up on these conditions by the use of draft gages over the fire, at the uptake and on both sides of the damper and at the base of the chimney. An analysis of the situation in this manner should indicate just where your trouble lies and how it may be remedied.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Your Duty to Vote

In time of war it is the duty of every citizen, regardless of sex or creed, to do everything in his power to help the nation. In rendering such national service, the citizen is adding weight to the side making for the betterment and the permanence of the country he calls his own. That the citizens of the United States have never failed, in time of need, to give the required service is evidenced by the fact we have never lost a war. Had the people of the United States, or even half of them, failed to do their duty in times past, we venture the assertion that the United States would have been defeated in past wars and that this would be a nation far different from what it is today—a nation less wealthy in material assets, less rich in liberty and freedom.

Every four years the citizens of this country are faced with an emergency. Not a war emergency, but one that is almost as important; whose consequences can be quite as far-reaching. And it is the duty of every citizen of the United States to render his national service at those four-year intervals; just as clearly as it is his duty to lend his help in time of conflict.

One of those stated intervals is not far off. The day is November 4. That day we elect a President of the United States. On that day we select the man we wish as our Chief Executive. Every citizen of the United States, regardless of sex, is entitled to vote. To vote is to render a national service. To vote is the duty of every citizen.

We are told by statisticians that in 1896 over 80 per cent of the voters cast their ballots. In 1900, 72 per cent of the citizens voted. In 1908, that percentage decreased to 66. In 1912, 62 per cent, and in our last election (1920), less than 50 per cent.

Less than half those eligible to vote in this country are casting ballots. That condition is a national menace. It is affecting the welfare of our country. Since the growth of public indifference to election days—since 1896—there have crept into our legislatures distinctly detrimental influences. Because of public apathy toward the exercise of our national birth-right, the vote, our government has been split into "blocs," factions and groups. The control of our government has fallen into the hands of those holding "the balance of power." That is a condition never intended by our fore-fathers. Regardless of who holds the "balance" of power the system is un-American. The word "bloc" doesn't even appear in American dictionaries. "Bloc" systems menace the welfare of our government. And it is largely because half the people of the United States do not vote.

We are not attempting to tell the reader how to vote. Vote for whom you please. We have no quarrel with personal convictions. The idea is—VOTE.

Good Business Ahead

Forty-six years ago the United States was neck deep in a business depression. In that year, 1878, grain prices were exceedingly low, being exceeded only by the farmer's spirits. The country was grappling with the problem of resuming gold payments. It was a dark year, made darker by bumper crops in Europe. This condition continued until the following year when, simultaneous with an almost complete crop failure in Europe, we raised a bounteous harvest. The following 5 yr. was a period of prosperity for the entire country.

In 1896, wheat was again low. Other grain prices were in a comparative state of depression. It was a lean year. But again came news of a crop failure abroad. Prices started forward, farmers had money and spent it, and there started one of the greatest periods of prosperity this country has ever known.

The most pleasant kind of prosperity does not necessarily come at the expense of another country or continent. It is true, however, that crop conditions materially affect our business conditions and recent reports indicate a serious crop shortage in foreign countries. It is estimated that the decrease from the 1923 yield will exceed 278 millions of bushels, in wheat alone. Canada confronts an acute shortage, her 1924 crop being estimated as 200,000,000 bu. short of last year. The prospective wheat yield in the United States is 3½ per cent greater than that of 1923.

Present indications are that the agricultural districts (with possibly a few local exceptions) will prosper this year. This, coupled with high prices born of foreign demand, will be a powerful force in making business conditions good throughout 1925. The farmer's prosperity today is helping swing the tide of business favorably. His buying power now stands 15 per cent above that of one year ago and is as high as it has been since the peak of 1920.

The impetus which agriculture is now receiving and will receive, should carry general business forward to another era of prosperity.

"Shading" Prices Is "Shady" Business

Without any doubt the old antipathy for the "middleman" grew out of the old practice of merchandising on the barter plan. Thirty and forty years ago, it will be remembered, clothing, shoes, meats and groceries were bought and sold on the principle of "the best man wins." The one who could haggle over prices most successfully was the one who walked out of the store in possession of the merchandise bought with the least expenditure in money.

This merchandising policy cost the time of both customer and salesman, created ill will and resentment on the part of the customer and lost patronage for the merchant. No doubt the agitation for the elimination of the "middleman" found its inception in the then prevailing mistrust.

Finally a far-sighted merchant (we believe the credit goes to the late A. T. Stewart) established a "one price to all" store, which subsequently changed all retail merchandising. The one fair price policy was too late, however, to forestall antipathy and unreasoning prejudice.

Considering the experience of the retailers, it is somewhat surprising to find supposedly reliable houses and reputable manufacturers given to the practice of "shading" prices. To say that such practice is unethical is trite. Nothing ethical, nothing of sound policy, is in such practice. Once a price is cut, the buyer immediately holds the seller in suspicion and wonders, henceforth, at how much

lower price his competitor secured the same goods. Unless every customer is sold from the same price list and at the same discount sheet, the price list is fraudulent and the seller is a fraud. To make a man a bid, then offer to "shade" the price if necessary, instantly advertises the fact that at least some of his methods are not honest.

Confidence is the cornerstone of business. That cornerstone can never rest on the quick-sands of suspicion. Cutting or "shading" prices threatens the cornerstone of real business.

A continuance of this practice is one sure way of impelling legislative action, one way of making for further governmental interference.

Long, Hard Winter Ahead

It is a matter of history that the year 1816 was one of extreme severity. During that year practically no crops were raised north of what was later known as the Mason-Dixon Line, and only a partial crop from the Southern States. A half inch of ice formed in New York City on July 4, 1816. That year was known as the "year without a summer."

History has been known to repeat itself. Weather experts and scientists at the Smithsonian Institute are inclined to the belief that during 1925, 1926 and 1927, it may do so, in this regard. And it must be remembered that present day weather experts have little relation to the old-time "weather man" whose "prognostications" had slight foundation in fact. Few modern sciences have developed more rapidly or deserve more respect than that of weather forecasting.

Through the recent developments of this science it is now possible to predetermine the general trend of weather 2 and 3 yr. in advance. Since 1905 weather experts have found that the penetration of the sun's heat does not affect our climatic conditions immediately. Rather, that the sun's heat intensity is delayed in its earthly effect from 1 to 3 yr. Since that time, also, they have been studying the "solar constant" continually; they discovered that the normal average is approximately "1.94 gram calories of heat per square centimeter of earth's atmosphere per minute." That is the way they measure "solar constant" and according to their records, 1.94 is the normal average.

Since 1922 these solar radiation values have decreased markedly. From May, 1922, to June, 1923, the "solar constant" was continually below 1.92 and since February, 1922, the constant has not reached the normal 1.94.

The material lowering in the sun's heat penetration during 1922 is given, by Mr. Browne of the institute, as the reason for our chill, backward and erratic summer (1924). The low tendency of the "constant" throughout 1923 and thus far into 1924 is given as the reason for the prediction that next summer and the one following will be increasingly cold, with a possibility of a return to the 1816 conditions—"a year without a summer."

Proof of the value of such research is to be had in present ocean temperatures. Scores of vessels have reported, during the past 6 mo., that oceanic temperatures are approximately 12 deg. below normal. This condition extends to practically all waters. Extreme snows and severe weather was reported throughout Scandinavia, Northern Europe, Scotland, Australia, and New Zealand during 1923-4 and unprecedented floods have been experienced in certain parts of South America and Africa during the past 12 mo. During July of this year light frosts were experienced in Illinois. These conditions are effects of the solar constant decline, according to the experts.

Considering that the weather man joke passed into oblivion along with the mother-in-law and horseless-carriage wheezes, it is our belief that serious thought should be given the available facts. With the highly developed instruments now employed and with the cumulative knowledge and experience on the part of the weather experts, such conclusions, however sombre, should be accorded an open mind. For it will be seen, upon thought, that a completely cold summer is not necessary to blight our crops and throw the northern half of the United States into wide-spread disaster. A killing frost during June followed by one in July would be sufficient to spell destruction to all agricultural products.

It has been reliably, though quietly, reported that several large and influential members of our electricity and gas producing industries are already laying plans for such a 3-yr. emergency. If you appeal to Mr. Browne of the Smithsonian Institute for additional and more detailed information, you also may see the justifiability of such preparation. Consideration also will show the necessity for quiet action.

Professor Cox, senior meteorologist of the U. S. Weather Bureau, shows no alarm at Mr. Browne's prediction, although he hesitates, even refuses, to discount it heavily. He points out that Mr. Browne changed instruments during his "solar constant" measurements and that such a change might have affected the "apparent" decline ranging from 1 to 2½ deg.

Let us hope Mr. Cox's, not Mr. Browne's attitude is right. Let us hope the solar constant continues to rise. Let us hope that disaster, as suggested, may not materialize. At the same time, we shall lose nothing by accepting, at least in principle, the conclusions of our scientists.

Is It Worth a Dollar?

Just suppose your wife was about to become a mother, but, never having had the experience before, knew nothing about the care she should give herself both before and after confinement. Supposing that, would it be worth a dollar to have a qualified nurse come into your home, spend hour after hour, and day after day, just teaching your wife how to endure the strain more easily?

Just suppose you were a soldier in France and that you had endured the screech of the shells, the patter of the machine guns and the hum of the air-craft until your every nerve was taut—until you jumped a foot at every little squeak—until you weren't worth a nickel either to yourself or to your company. Supposing that—would it be worth a dollar to be put in a quiet ward in some hospital or in a remote chateau where you could just rest and forget?

Just suppose you were in a terrible flood and that your home has been ruined, leaving you destitute, without a place to lay your head. Suppose your wife and kiddies were with you and in your destitute condition you could not provide even shelter for them from the incessant rain. Suppose that—would it be worth a dollar to have some man give you, without cost, a little tent, some hot coffee and a loaf of bread?

Would it be worth a dollar to belong to an organization that does that sort of thing constantly?

Well—between November 11 and November 27 you are going to be asked to contribute a dollar to the Red Cross.

EDITORIAL COMMENT

Industrial Power Plants Benefit by City Zoning

As villages grow into towns and towns into cities, unless some rather definite plan has been agreed upon, the different industries are likely to be scattered throughout the entire city not according to the best interests of the city as a whole but according to land values and individual ideas of the founders of the industry.

Throughout the United States, 261 municipalities have zoning ordinances. Secretary Hoover characterizes these ordinances as "reasonable, neighborly agreements as to the use of land." Their legal right to existence is for the purpose of promoting health, safety, morals and general welfare of the entire community.

As affecting power plants serving industrial establishments, zoning regulations may have a decidedly beneficial economic result, if advantage is taken of the proximity of plants to carry out on a larger scale some of the necessary provisions of every plant which are in many cases quite expensive, due to their limited use.

In the handling and storage of coal, for instance, several neighboring small industries can well afford to pool their interests in a common coal yard equipped with modern facilities for unloading cars and storing coal for emergency use, trucks and truck loading machinery. The disposition of ashes is another problem which, in many cases, can best be solved by a system of trucks operated by several neighboring power plants.

City zoning also makes convenient the interconnection of steam and electric lines between adjacent factories or buildings. Although a plant may be properly designed for the service it is to perform, seasonal fluctuations may throw its economy somewhat out of balance. Frequently a survey of the steam and power needs of neighboring factories will reveal that an interchange of services will result in advantages to both plants.

Nearly every power plant, no matter how small, has space reserved in which to make repairs. It is usually so inadequately equipped that it cannot be called a repair shop and when work of any size or importance is to be done the parts must be sent to some distant shop. In a factory district where several power plants are located, the amount of repair and machine work done would be sufficient to maintain an up-to-date shop which could be conveniently located to serve all the power plants and, with an expert machinist in charge, repairs could be made under the supervision of the engineer of the plant much more satisfactorily than in the plant or at a distant shop.

More than a passing interest in zoning is being shown by cities and villages throughout the entire country and, as ordinances come up for consideration, engineers should be prepared to make recommendations which will be of immediate benefit to their industry and permit its indefinite growth for generations to come.

At Your Service

Service is the keynote of present day business; the very backbone of modern industry. In the final analysis it is the ultimate product of the manufacturer, of the distributor and of the salesman and it is that which the ultimate consumer utilizes to satisfy his many and varied requirements. Any producer, no matter what his product, must sell service as it is only in this way that he can long endure. Repeat orders are obtained only through customer satisfaction which can result only from efficient service. It is only the fly-by-nighter who ever attempts to market a commodity without, at the same time, selling its capacity for service.

When you buy coal, you are not particularly interested in the product as such; you really are buying heating service, the capacity to produce certain specified results. When you buy lubricating oil what you are after is lubricating service and that is what you are willing to pay for. The same thing holds true for every other conceivable marketable commodity.

That being the case, are you making the best possible use of what is being offered you?

Many of the larger organizations even go to the expense of maintaining a customer service department composed of a staff of highly specialized engineers whose sole duty it is to recommend methods of operation in a customers' plant whereby the maximum possible amount of service can be realized from their product. Such co-operation results in better satisfied customers which are of course a credit and a specific asset to any company, but the point here is that the customer is also greatly benefited; this service saves him money.

Take as a notable example the question of lubricating service. Most of the oil refiners have a staff of engineers who go into plants where some difficulty is reported and make a careful analysis of the operating conditions. One of these men will make up a complete list of equipment, taking note of any unusual operating conditions and, after careful study, will make specific recommendations as to the correct lubricating service for each machine, taking into consideration what disposition is to be made of the used oil, i. e., whether or not it is to be reclaimed, the importance of oil-free exhaust, for instance, and such operating problems. He can make suggestions that will effect more efficient and more economical application. He will give you an estimate of what your normal consumption should be. He will consider with you any special problems that may come up, even to the extent of submitting them to the company's research laboratories for solution.

Are you taking advantage of this service? If there is any part of your plant that is not functioning exactly as it should, get in touch with the manufacturers concerned; they may be able to offer some exceedingly helpful suggestions as to how you may cut down your operating costs.

Electrical Power Equipment Number

JANUARY 1, 1924, ISSUE WILL BE DEVOTED TO THE THEORY AND PRACTICE OF ELECTRICAL MACHINERY

NEARLY ALL modern electrical equipment depends on electro-magnetic action for its functioning. It is essential, in order to understand the action of electrical apparatus, that one have a thorough knowledge of electro-magnetic action; how electro-motive force is set up by the motion of a conductor in a magnetic field and how to determine the value of the electric potential difference which will be produced for a given set of conditions. Also how to set up a magnetic field by a coil carrying electric current, how to determine the strength of that field and what as well as how much force will be exerted on a conductor carrying current when it is placed in a magnetic field.

These basic principles will be taken up and fully discussed in the first section of the issue.

ACTION OF DYNAMOS

As generated in dynamos, electro-motive force is always alternating, rising and falling in a periodic cycle. Just how this comes about and how conductors are combined into coils, coils into circuits and circuits connected together to get a steady voltage at the machine terminals and to produce two and three-phase currents, will be shown in this section. Also the method by which half the current is reversed in the outside circuit, through the commutator, so as to get direct current, will be explained.

DIRECT-CURRENT GENERATORS

Production of the magnetic field requires the use of field coils and poles and a frame through which the magnetic flux can travel. Also the strength of field must be controlled to adjust the voltage to load requirements. Types of winding, cores, frames, rheostats and special methods such as movable field cores and interpoles are included in the discussion of field construction.

Generation of voltage in the armature requires windings to cut the field and carry the current, also a core to serve as a path for the magnetic flux and as a support for the coils. The principles and details of armature construction will be fully treated.

To get direct or continuous current, the current must be rectified as it leaves the armature, which necessitates commutation. This involves proper size, details and connection of commutator, brushes and brush rigging, all of which will be carefully considered.

Operation in series to give higher voltages and in parallel to give higher currents involve special problems of voltage control, connections and current control. To save copper in the circuit, the 3-wire system is used, a special form of series operation. Requirements of all these systems and how to meet them will be fully explained.

ALTERNATING-CURRENT MACHINERY

Conditions to be met by alternating-current machines differ from those for direct current requiring different construction of poles, cores, coils and frame. The why of these differences and the changes necessary in details, as well as how the use of a.c. machines differs from that of d.c., will be the subject of this section.

Excitation by direct current, the form, size needed and provision for driving exciters will be considered; also the method and means of controlling the excitation of alternators.

Details of construction of all parts of a.c. machines to show current good practice, details of operations for synchronizing and paralleling, control of load on machines in parallel and special means for overcoming difficulties are some of the topics to be discussed.

For transmission, high voltages are desirable because of the saving in copper in the circuits. For generation and utilization, lower voltages are desirable as insulation problems are simplified and there is less danger to operators. Raising and lowering electromotive force is most easily accomplished by stationary transformers which may be designed to deliver a constant current, a constant voltage or voltage varying by steps and to step up or step down the electromotive force. Details of the various types of transformers, the function of cores, coils, taps; how they are constructed and connected up and the proportioning to ensure minimum copper and iron losses for given conditions will be the subject matter for this section.

MOTORS

Why does a motor mote? And which kind will mote best for a given set of conditions? Some must carry a varying load at constant speed. Some have a constant load but the speed must vary. Some have to work at all kinds of loads and speeds. Which kind of motor fits which conditions? And how can speed be best controlled? These are questions likely to arise at any time. The answers will be found in this issue.

INSTRUMENTS

For modern efficiency, not only must machinery operate and carry the load, but it must do so at minimum cost. To ensure that conditions are right and power is not wasted, the engineer must be able to measure voltage, current, power factor, frequency, wattage, wave form, insulation resistance. This requires many instruments of various forms and types as well as a knowledge of how they work and how to use them for regular operation and for periodic tests. To give this information will be the purpose of this section.

CONTROL OF THE SYSTEM

Voltage must be regulated. Output of generators must be controlled and subdivided among circuits. Generators must supply sometimes one part of the load, sometimes another. Overload must be prevented. Electric plant and steam plant must be able to communicate quickly so as to meet varying load conditions.

All this requires switching apparatus of great complexity, interconnected bus bars, protecting devices for machines and circuits, signal systems and indicators. And this section will show by what apparatus and systems these conditions are met.

In this issue the reader will be supplied with a text and reference book covering all the electrical equipment which he will have in charge in the most modern plants and factories and which will enable him to operate such equipment understandingly and successfully.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Long Bell Lumber Co. Plant in Operation

18,000-Kw. Oil and Wood Fired Plant at Long View; Wash., Supplies Power for Long-Bell Sawmill

ONE OF the interesting industrial developments of the year is that of the Long Bell Lumber Co. at Longview, Wash. In building one of the largest sawmills in the world at this location the organization has had to erect an entire town and has provided power generating facilities for its operations. Some idea of the magnitude of the work may be gained from the fact that the initial capacity of the power station is 18,000 kw. and it has been designed so that the capacity can be increased to 36,000 kw. The first pile for foundations was driven on June 18, 1923, in just one year, on June 18, 1924, J. W. Martin, construction manager of The Long-Bell Lumber Co., lighted the first fire under the boilers.

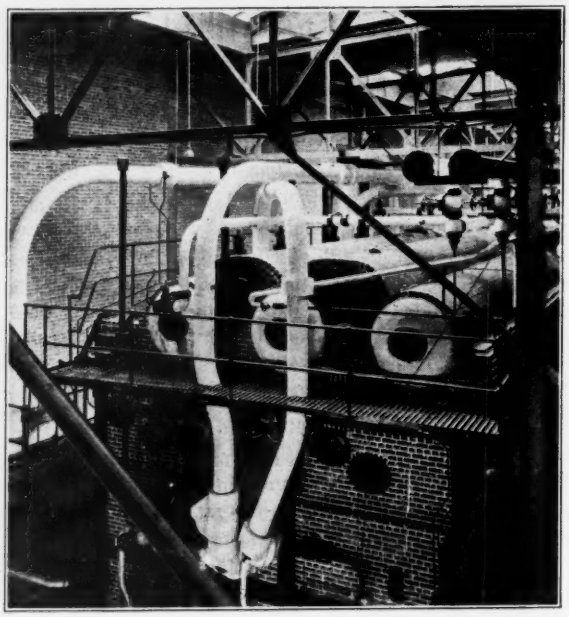


FIG. 1. EIGHT 1200-HP. STIRLING BOILERS SUPPLY STEAM AT 250 LB. PRESSURE AND 125 DEG. SUPERHEAT

The present power plant building is 192 ft. wide and 296 ft. long, and the equivalent of about five stories in height. The three permanent walls in the building are built of concrete brick, finished on the outside with fire flashed brick of the same material. In connection with the plant, there are two reinforced concrete chimneys, each 21 ft. inside diameter at the top and 300 ft. high, stacks being designed to serve the ultimate plant.

Belt Conveying System for Wood Fuel

Belt conveyors are used for carrying the wood fuel from the fuel house to the boiler plant; these conveyors are 48 in. wide, troughed and, in some instances, run at rather steep angles. The boiler feed conveyors consist of cables with cast steel flights, and are operated by means of gap wheels and reduction gears. A total of four boiler feed conveyors is installed, two conveyors feeding the boilers on each side of the boiler house. All conveyors are motor driven, and the control of the conveying equipment is automatic. When the conveyors are started up by pushing the master control button, they start with a time element between each one in order to reduce the starting load and prevent an excess of fuel collecting at any transfer point. This control is secured by means of automatic time relays. All of the conveyors in operation can be shut down by pushing one button. The fuel storage house with its conveying system was installed by the engineering staff of The Long-Bell Lumber Co.

Eight 1200-hp. Babcock & Wilcox Stirling boilers, designed for 250 lb. pressure and supplied with superheaters to give about 125 deg. superheat supply steam to the turbines. The boilers are set with large extension furnaces and big combustion chambers. The boilers were designed, and guaranteed to operate, at a maximum of 200 per cent rating but actually will exceed this.

Makeup water is secured from wells adjacent to the plant, the water being treated in a cold process water softener and filtered through pressure filters. Filtered water is also used for various other purposes about the plant. The water filtering and treating equipment was supplied by the Cochrane Corporation.

Three 6000-kw., 13,200-v., 60-cycle General Electric turbo-generators are installed in the turbine room. The power is distributed through a General Electric switchboard, remote control switches being used throughout. Direct-current motor generator sets with a storage battery floating on the line furnish control current for the switchboard and also power for emergency lighting.

Besides a motor generator exciter set, a dual drive exciter is installed, having a steam turbine and a motor drive, either one capable of operating the exciter at full load. For purposes of heat balance the load can either be carried by the turbine or the motor, or by both. The plant also contains two 250-kw. direct-current motor generator sets to furnish power for cranes and other electrical equipment about the yard and sawmill.

Power for 2200 and 440-v. station auxiliary motors is supplied by a bank of three 1500-kva. three winding transformers, an additional transformer being installed as a spare. Starting and running oil circuit breakers for all 2200-v. motors are located in a concrete and transite station auxiliary bus structure. The starting bus in this structure is supplied by a specia bank of starting compensators.

There is installed one large motor-driven air compressor, which furnishes compressed air for the sawmill. A small motor-driven air compressor furnishes air for general power plant service.

Condensing equipment consists of three surface condensers and auxiliaries manufactured by the Wheeler Condenser & Engineering Co. Wheeler steam jet air pumps of the two-stage type, with surface inter and after condensers, are used. Duplicate hot-well pumps of centrifugal type are provided for each condenser, one with a motor and the other with a steam turbine drive.

Circulating Water Supply

Circulating water is taken from the log pond adjacent to the plant, water being taken from the Cowlitz River through a canal to the main storage pond, thence through additional canals to the pond adjacent to the plant. All of these waterways were dredged, material being used for diking purposes. There are four Wheeler centrifugal circulating pumps of different capacities, two small pumps each being designed for full load on one turbine, and are operated one by steam turbine and the other by motor. The large pumps are motor driven and of different capacities. Water from the log pond is screened through revolving Chain Belt Co. screens into a concrete intake well, from which separate suction lines run to the pumps. The pumps discharge into a header from which water is taken to the condensers and discharged into a header running over the dike into the Columbia River. When the plant is extended, a second discharge header will be added. A check valve is provided in the discharge line to prevent water from siphoning back into the plant in case of a broken pipe line. Each circulating pump is protected by multiport check valves and electrically operated gate valves, so that any pump can be shut down for inspection and repairs. The check valves are of special construction for the service required.

The installation of the circulating water intake with screens was a difficult problem, the soil being loose sand and gravel. The bottom of the intake had to be located considerably below water level. Both ordinary and sheet piling had to be used to prevent settling and to prevent the bottom from flowing upwards, so that finally, within a cofferdam, the excavation had to be made under water and concrete placed under water. After the bottom was sealed, the construction was completed inside the cofferdam. Separate motor driven pumps at the power plant, taking their suction from the screen chamber, furnish water for washing the screens, the debris being drained to waste.

Two Cochrane open storage type feed water heaters are used, either one of the heaters being large enough for ordinary purposes, but the storage space of the additional heater being used as a reservoir to prevent wastage of hot water, the additional heater being used for breakdown service and will be used continuously in the ultimate development of the plant. A large amount of hot water is returned more or less intermittently from the dry kilns of the sawmill. This water is of good quality and at high temperature, and cannot profitably be wasted to the sewer.

A complete system of ash sluicing is provided, with a large ash pit under each boiler, with flooding pipes and a system of sloping concrete trenches running to two motor-driven, specially designed ash pumps, which discharge the material into a concrete ash pump outside the building, from which ashes are removed by locomotive crane.

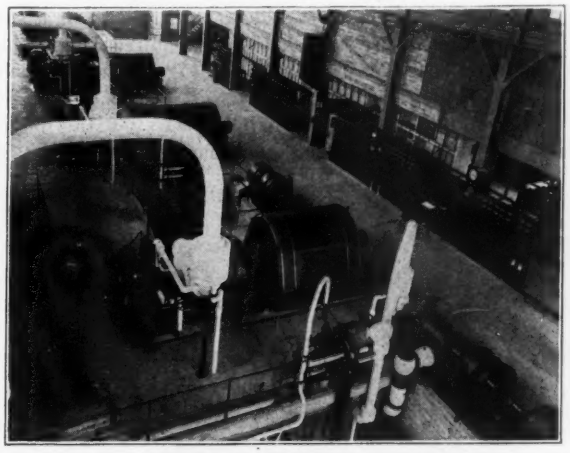


FIG. 2. THREE 6000-KW. UNITS NOW INSTALLED MAKE UP HALF OF THE ULTIMATE INSTALLATION

On account of the debris which might be in the water, the oil coolers for the turbines were supplied with extra large tubes. Special centrifugal pumps take the cooling water from the intake and discharge it to storage tanks on the roof of the power plant, in order to provide a continuous supply of water to the turbine bearing oil coolers. The water, after being passed through the turbine oil coolers, is discharged to waste.

Each turbine is provided with Spray Engineering Co. Air Washers for cleaning and cooling the air. Air is taken from the turbine room basement and is discharged through galvanized iron ducts to the outside of the building.

The plant was first started with oil fuel, and four of the boilers are equipped to burn oil as an auxiliary. To start a plant of this kind it would be practically impossible to fire enough slab wood, wherefore the oil fuel was used in order to get the plant started and to obtain a regular supply of mill refuse fuel for the boilers.

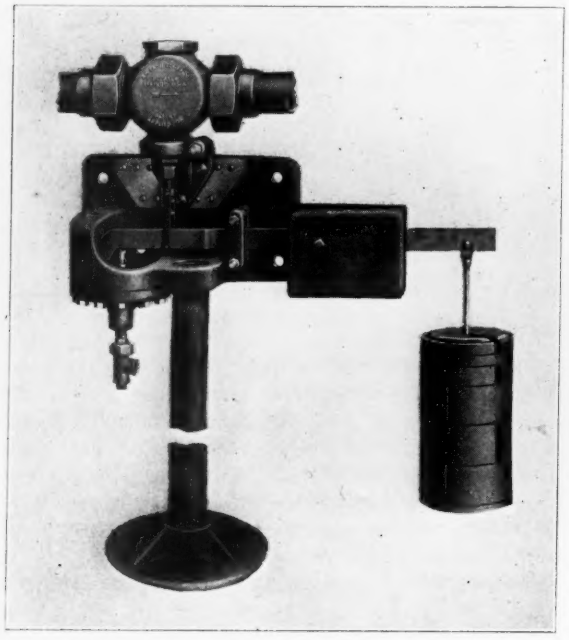
Chas. C. Moore & Co., engineers and contractors of San Francisco, designed and built the power plant.

Average daily production of electricity by public-utility power plants in August was 152,700,000 kw.-hr., 2⅔ per cent greater than the revised figures for the daily output for the month of July. The curve of total output for 1924, indicates that the seasonal decrease in the demand for electricity was over in July. The total production of electricity from January 1 to July 31 of this year was 33,706,000,000 kw.-hr., about 5½ per cent greater than the output for the similar period of 1923. The production of electricity by the use of water power continues to decrease, indicating that the end of the low-water period has not yet been reached.

Regulator Changes Fan Speed

ONE of the recent developments of the A. W. Cash Co., Decatur, Ill., is a fan engine regulator controlled by varying boiler pressure and bringing about compensating changes in fan or blower speed. In bringing out this regulator the manufacturers state that: "The fallacy of the straight line chart, of keeping boiler pressure constant especially where there is a wide variation in demand, has been pointed out and generally agreed upon. The exact amount of steam required to drive the fan engine or blower is seldom known and it is seldom clear just what exact change in boiler pressure should be required before the regulator is opened fully and the fan engine brought from idling to full speed."

As shown in the accompanying illustration this regulator consists of a diaphragm counter-balanced by a



CHANGES IN STEAM PRESSURE MOVE DIAPHRAGM AND ACTUATE A BALANCED VALVE

weighted beam which transmits the pressure change impulses through a link, to the balanced valve which supplies steam to the fan engine. Any decrease in boiler pressure causes a downward movement of the beam, an increase in valve opening, and therefore a gradual pick-up in fan speed. An increase in boiler pressure decreases the valve opening and decreases the fan speed smoothly until the fan is idling when normal boiler pressure is reached. Each definite change in boiler pressure is therefore accompanied by a definite change in fan speed.

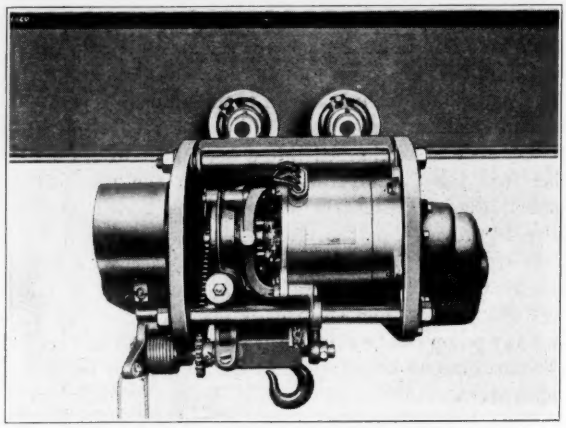
In commenting on the operation of the regulator the manufacturers state: "Assume that good engineering requires an operating range of, say, 6 lb. on a certain installation. If the desired normal boiler pressure is 180 lb., the fan engine should be idling at that point and for economical reasons be brought up to full speed only when boiler pressure drops to 174 lb., should it fall that low. There should be a lag between the boiler pressure curve and the fan speed curve.

"With this device the amount of valve opening for a given change in pressure may be determined by the position of the valve in relation to the beam. Note that with expansion joints installed before and after the balanced valve it may be shifted along the positioning pad and the connecting link connected to the beam at the corresponding hole. In this way a definite, fixed amount of valve travel may be established in relation to a definite, fixed and scientifically desirable change in boiler pressure."

For saturated steam service these fan engine regulators are good for pressures not exceeding 250 lb. For 250 lb. pressure, and 600 deg. F. total temperatures, the regulators are made with steel bodies, monel mounted. In all regulators for saturated steam service the balanced valve is made entirely of bronze except sizes 2 and 2½ in., which are of iron, bronze mounted. For superheated steam the valve proper is steel, monel mounted, as indicated above. Knife edges and bearings are hardened steel. The diaphragm is of rubber and the supporting frame, weights, and diaphragm hood are gray iron.

New Hoist Designed for Low Headroom Applications

OPERATION under minimum head room conditions is a feature of a new electric monorail hoist which has been developed by the American Engineering Co. of Philadelphia in half-ton and one-ton sizes. This hoist retains



MOTOR MAY BE REMOVED WITHOUT INTERFERING WITH LOAD ON HOOK

the features of the line of "Lo-Hed" hoists built by this company, but is smaller and lighter than the other members of the "Lo-Hed" family and is intended for general utility use where a light hoist is needed.

Due to its ability to draw up the load hook until it almost touches the rail, the hoist is suitable for use in places where, because of low head-room, no other hoist could be operated. It gives additional clearance and safety for bulky loads and makes it possible to pile materials higher than could be done in any other way, thus increasing the capacity of warehouses by utilizing the space almost to the ceilings.

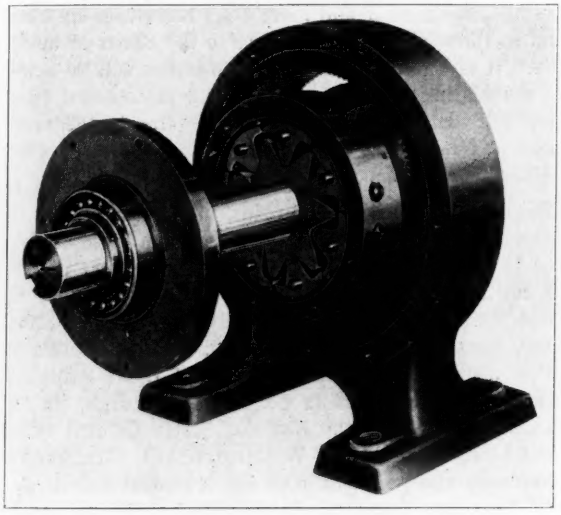
Automatic holding and lowering brakes are provided and a safety device checks the hoist and throws off the current when the upper limit of travel is reached. High duty

roller bearings and automatic lubrication give an efficiency of eighty per cent. A factor of safety of at least five makes overloads possible in emergency.

These hoists are furnished for either direct or alternating current. All working parts are accessible and the motor can be removed for repairs in a few minutes without touching the load on the book.

Speed Reducer Is Designed to Reduce Starting Shocks

SEVERAL novel features have been incorporated in a speed reducer which has recently been developed by the Meachem Gear Corporation, 122-124 Dickerson St., Syracuse, N. Y. In this speed reducer the load is transmitted from the high speed shaft through planetary gears to a slower rotating annular ring. Inside this ring are connected a number of rockers which engage with a spider keyed to the low speed shaft.



SPRING PLUNGERS TAKE UP SHOCKS

As the driving motor or turbine starts up, each of the rockers engaging with the teeth of the spider, first compresses a spring plunger which brings the inside of the annular ring and at the same time brings its side into positive contact with the side of the adjacent spider tooth.

During the time required to compress the spring plungers, corresponding to about one-quarter of a revolution, there is practically no load on the turbine or motor, and the load is then transmitted gradually and without starting shock. The spring plungers also serve to eliminate vibration and backlash, thereby assisting quiet operation. The low speed shaft to which the spider is keyed, is supported on both sides of the spider. The pinion on the high speed shaft is allowed to float and adjust itself to the proper position between the planetary gears, thus preventing side strains or unequal stresses, and assuring perfect torque.

The speed reducer is totally enclosed, so as to be dust proof and all parts run in oil, with forced lubrication above 1800 r.p.m. It can be applied to either step-up or step-down speed change, and is furnished in ratios from 4:1 to 200:1 and for any load up to 500 hp.

Plans for A. S. M. E. Annual Meeting Are Taking Form

THIS year the 45th annual meeting of the American Society of Mechanical Engineers will be on Dec. 1 to 4 and, as usual, at the Engineering Societies Building in New York City. For the third consecutive year the meeting will be held coincident with the Power Show. Plans for the various meetings are assuming tangible form. The technical program gives promise of a great wealth of important material. The Machine Shop Practice Division will participate in several sessions: The first in co-operation with the Special Research Committee on Cutting and Forming Metals which will discuss various methods of measuring hardness; the second, with the Special Research Committee on Lubrication at which there will be several papers giving results of recent researches in high-pressure lubrication; the third, with the Management Division in a session devoted to production control; and the fourth, a General Session to consider mechanical springs, inaccuracies in gear teeth and other design problems.

As usual, there will also be several sessions devoted to consideration of the important discussions of power problems, the Power Division sponsoring a session on steam power with papers dealing with boiler water conditioning, resuperheating in steam turbines, pulverized fuel, and the burning of small sizes of anthracite. This Division will also co-operate with the Fuels Division in a session on oil burning at which papers on marine practice, industrial practice, and the hazards of oil burning will be presented. A session on hydraulic power, also sponsored by the Power Division, will take up penstock and draft-tube design. The Oil and Gas Power Division is planning a session with papers on the gas turbine and the solid-injection engine.

Many interesting papers are also planned for the management, Railroad, National Defense, Aeronautical, Textile and Forest Products Division of the Society.

Stocks of Anthracite and Bituminous Coal Show Decrease

COAL STOCK figures compiled recently by the Government revealed the following facts: Commercial stocks of soft coal on September 1, 1924, totaled 47,000,000 net T., a decrease of 4,000,000 T. from stocks on June 1, and 15,000,000 T. from the record of January 1, 1924; the course of stocks has been constantly downward since the early weeks of the year; stocks on September 1, 1924, were 9,000,000 less than on the same date a year ago, and were then double those on September 1, 1922, at the close of the miners' five months' strike; compared with August 1, 1921, there was an increase of 6,000,000 T.

Measured in terms of tons, stocks decreased 24 per cent during the first 8 mo. of 1924. Measured in terms of days' supply, the decrease was but little over 2 per cent. These percentages are based on averages which assume that the supply was evenly distributed. Stocks are never evenly divided, however, and the use of such averages is proper only for the purpose of comparison. There are those in every community who habitually carry small or even no reserve stocks.

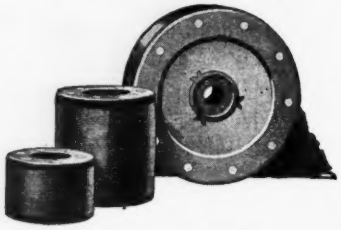
In addition to the estimated quantity in storage piles of actual consumers, the following quantities are known to

have been in transit on September 1: On the commercial docks of Lakes Superior and Michigan, 6,600,000 T.; in storage at the mines or at intermediate points, at least 300,000 T.

Retail dealers' stocks of anthracite were 71 per cent larger on September 1, 1924, than they were on the corresponding date of 1923, and they were but 7 per cent less than on November 1, 1921, two months later in the season. As a result of the steady movement of anthracite up the Lakes the stocks, which stood at 450,000 T. on June 1, had increased to 1,400,000 T. by September 1.

Paper Pulley Has Double Locking Hub

ONE feature of a new line of paper pulleys, recently placed on the market by the Best Pulley Mfg. Co., St. Louis, Mo., is the use of a patented double locking hub which has three sets of two ribs each which grip into the paper and prevent the hub from coming loose, even though the pulley may be reversed in direction. These ribs are a part of the hub and extend out from the hub in a V shape so that when the hub is hydraulically pressed into the pulley it becomes an integral part of the pulley.



V-SHAPED RIBS ON HUB KEEP PULLEY FROM SLIPPING

In building these pulleys, treated paper is hydraulically compressed into a solid block. The end grain of the fiber is exposed to the belt so that belt slippage will be reduced.

It is stated that the pulleys are to be built in 2500 stock sizes.

News Notes

CONSOLIDATION of public utility companies seems to be in the air this year. The latest reported is the Continental United Power Co. which takes in the Continental Gas & Electric Corp., Columbus Railway Power & Light Co., United Light & Power Co., Kansas City Power & Light Co. and Lincoln Gas & Electric Co. The combined installed capacity of the generating stations is 340,000 kw. and gas output in excess of three billion cubic feet a year, giving gross business of $34,000,000 annually. Territory served is in Ohio, Michigan, Iowa, Missouri, Kansas and Nebraska including the cities of Columbus, Grand Rapids, Grand Haven, Muskegon, Davenport, Cedar Rapids, Fort Dodge, Rock Island, Moline, Kansas City and Lincoln, the combined population being 1,750,000. This puts the new consolidation in the class of the Standard Gas & Electric Co., Pacific Gas & Electric Co., Illinois Power & Light Co., Middle West Utilities Co., American Water Works & Electric Co. and New York Edison Co. Cyrus S. Eaton will become Chairman of the Board of the new company, Frank T. Hulswitt, president, and as vice-presidents, Rufus E. Lee, Richard Schaddelee, B. J. Denman and William Chamberlain. On the Board of Directors will be Joseph F. Porter, Landon K. Thorne, Burton A. Howe, Warren H. Snow, L. H. Heinke, William Butterworth, Glenn M. Averill, C. H. McNider and T. H. Jones.

ANNOUNCEMENT was made recently of the establishment of Lehigh Institute of Research by the administration of Lehigh University. The management of the new organization, which was authorized by the Board of Trustees on April 25, 1924, is vested in a Board of Directors composed of 13 members of the University's staff, including President Charles Russ Richards. Each man is a recognized authority in his special field. In announcing the purposes of the Institute, the Lehigh Board of Trustees, of which E. G. Grace, President of the Bethlehem Steel Corporation, is president, stated that the object is "to encourage and promote scientific research and scholarly achievement in every division of learning represented in the organization of the university; and in recognition of the need for further and more exact knowledge in science and in the applications of science to the affairs of modern life. It is believed that this organization will be helpful in stimulating interest in liberal and professional education and that it will prove to be of value to the professions and industries of the nation."

NATIONAL PROBLEMS of accident prevention in America affecting the industries, railroads, mines, the schools, the homes and the general public were given close study at the 75 sessions of the Thirteenth Annual Safety Congress of the National Safety Council held at Louisville, Ky., Sept. 29 to Oct. 3. Approximately 3500 were in attendance, including representatives from Canada, Alaska and other distant parts. Carl B. Auel of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., was elected president of the National Safety Council to succeed Lewis A. DeBlois of Wilmington, Del. Mr. Auel was previously vice-president in charge of general activities and has for years been actively identified with the accident prevention work of his own company and with the safety movement at large. Mr. DeBlois becomes vice-president in charge of general activities.

FRED R. LOW, editor of Power and president of the American Society of Mechanical Engineers, was the recipient of a degree of Doctor of Engineering from Rensselaer Polytechnic Institute in Troy, New York, during the celebration of the 100th anniversary of that engineering college.

REORGANIZATION of the Anderson Foundry & Machine Co. has been perfected and will immediately commence full operations under the new corporation known as Anderson Engine & Foundry Co. The type "K" Anderson engine will be placed on the market, greatly improved, in the same sizes as previously marketed, 30 to 325 hp.

FREDERICK TREAT, chief operating engineer of the Pittsfield Electric Co., Pittsfield, Mass., has been appointed a member of the State Board of Boiler Rules, representing the operating engineers. He has been in the employ of the Pittsfield Electric Co. for 32 yr.

HAROLD S. HALL, formerly with the Grinnell Co. and General Fire Extinguisher Co., has joined the sales department of the Pittsburgh Valve, Foundry & Construction

Co., Pittsburgh, Pa., and will have charge of the company's new sprinkler equipment and factory heating department. A complete line of fire prevention apparatus, approved by the Underwriters, has been selected and a capable staff of engineers engaged to assist Mr. Hall in the direction of this new department.

THE O. E. FRANK HEATER & ENGINEERING CO., 80 West Genesee St., Buffalo, N. Y., has been organized by Olive E. Frank to manufacture a line of U-tube and straight tube storage heaters, also a line of instantaneous heaters for hot water and feed water service, and use in large power plants and forced and gravity heating systems. The Farrar & Trefts, Inc., plants have been secured to provide the manufacturing facilities and John Trefts, president of that organization will be a member of the new corporation. R. N. Crandall, chief engineer of the Industrial Planning Corporation will be the third member of the firm. Previous to embarkment on her new venture Mrs. Frank served for a number of years as sales manager of the Alberger Heater Co. and as manager of the expansion joint department of the Howard Iron Works. Mrs. Frank is a member of the American Society of Heating & Ventilating Engineers and has directed the engineering department of her former employers for a number of years.

CONTRACT has been secured by the Fuller-Lehigh Co. for a pulverized coal equipment to handle between 350 and 400 T. of coal a day, to be installed at the Holtwood, Pa., plant of Pennsylvania Water and Power Co. This includes complete drying, pulverizing and transporting equipment, and is to handle either anthracite or bituminous coal as may be required.

Other contracts recently secured by the Fuller-Lehigh Co. for pulverizing and burning equipment are from the Weirton Steel Co., the U. S. Metals Refining Co., Ball Brothers Co., Central Iron and Steel Co., American Spiral Pipe Works and the Ford Motor Co.

NORTHERN EQUIPMENT CO. of Erie, Pa., manufacturer of feed water regulators, has appointed E. L. Bowers as advertising manager. For the past 6 yr. Mr. Bowers has been assistant advertising manager of the White Motor Co. of Cleveland; previous to this, he was connected with the Advertising Departments of the Packard Motor Car Co. and the Maxwell Motor Co. of Detroit.

A. A. HUTCHINSON, former manager of the Eastern Coal and Export Co. of Richmond, Va., and more recently president of the Hutchinson Engineering Co. of Birmingham, has joined the field service staff of the Quigley Furnace Specialties Co. of New York in the capacity of assistant traveling sales manager, making his headquarters in Atlanta.

ARTHUR L. MULLERGREN, consulting engineer, Gates Building, Kansas City, Mo., has been retained by the city of Faribault, Minn., to make a complete report for a municipal electric light and central heating plant and electric distribution system. The estimated cost of the entire project is approximately $450,000.00.

O. E. MORRIS, who has for the last 12 yr. been general superintendent for the Henderson Cotton Oil Co. in Texas, Arkansas and Louisiana, has accepted the position of chief engineer for the five plants of the Texas Ice & Cold Storage Co. in Dallas, Texas.

SOUTHERN MINNESOTA GAS & ELECTRIC CO. of Albert Lea, Minn., is increasing its boiler-room capacity by the addition of a new 875-hp. B. & W. cross-drum boiler which will be set in a new addition to the present boiler room. Other equipment includes Taylor stokers, Terry turbine and a Green fan. Frank E. Chase of Chicago drew the plans and the company is doing the installing under the direction of its chief engineer, F. M. Squires.

GRAYS HARBOR RY. & LT. CO., Aberdeen, Wash., is enlarging its plant to meet the rapidly increasing demand for power in the Grays Harbor region. The engineering work is being done by Sanderson & Porter.

One 1090-hp. Casey-Hedges Boiler will be added to the present bank of 4 B. & W. 400-hp. boilers. A 5000-kw. Westinghouse turbine is also being added. W. S. Hill is plant superintendent, and H. A. Bradner, chief engineer.

Books and Catalogs

ENGINEERING IN AMERICAN INDUSTRY, by Conrad Newton Lauer; 94 pages, size 9 by 12 in., cloth, $2.50; New York, 1922.

The story of industrial development in the United States is one of absorbing interest to any true American whether he be banker, lawyer, capitalist or laborer but it is of particular interest to the engineer because he has been so intimately connected with it and it is largely through his efforts that this development has been possible.

This review of our progress in industry is taken from a lecture delivered at Princeton University in 1923. It is told in an interesting story form and is easily read. The book is bountifully illustrated with photographs, drawings and charts, the latter constituting a valuable collection of statistical data.

This history covers a period of about 120 yr. from 1803 to the present day. The author begins his story at about the time of Robert Fulton and DeWitt Clinton, the beginning of modern transportation systems and carries on through the time of Corliss to our present methods of rapid transportation and communication.

THE AUTOMATIC CONTROL OF COMBUSTION is a new publication issued by the Carrick Engineering Co., 538 S. Clark St., Chicago, Ill. It discusses automatic control methods and systems and brings out the limitations of the various systems and why they fail. It analyzes the condition to be met in co-ordinating supply of steam with the demand and gives some interesting charts of steam pressure. Another bulletin by this same organization is entitled Systems for the Automatic Control of Combustion, in which complete specifications, together with diagrams and list of equipment required for 33 distinct methods of automatically controlling boiler room equipment are given. Thirteen different methods of controlling powdered coal are included.

IN A 94-PAGE BOOKLET published by the General Refractories Co. of Philadelphia, Pa., a complete outline is given of the various types of refractories manufactured by that organization. In addition some information, including photographs, is given regarding the various fire clay works which form a part of the General Refractories organization. The various shapes of the product are shown in perspective with the dimensions of the different faces.

BREEZO-FIN HEATERS, a new type of unit heater, are described in a bulletin issued by the Buffalo Forge Co., of

Buffalo, New York. A series of heater tubes, the unit casing and the fan and motor constitute the component parts. The heater tubes of copper are wound with a copper ribbon, which is said to increase the radiating surface of the coils and thereby affords rapid transmission of the heat. Either steam or hot water may be used in the heater tubes and the fan forces the air through the heater. The fan used is of the Buffalo Breezo type equipped with 10 special cup shape blades. It is stated that the space required by this unit heater is much smaller than that required by heaters using other forms of radiating surface.

FREDERICK CENTRIFUGAL PUMPS are described in a new bulletin H-3, which is now being distributed by the Frederick Iron & Steel Co., Frederick, Md. These pumps are built in multi-stage, double suction volute and single suction volute types. The bulletin takes up the general operating characteristics and then proceeds to describe the details of construction for the different types. Cross-sectional views with dimensions and illustrations of different driving arrangements make up the balance of the bulletin. Another bulletin issued by the same organization is devoted to centrifugal paper mill pumps for handling stock.

U-FIN COOLERS are covered in bulletin No. 1216 now being distributed by the Griscom-Russell Co., 90 West St., New York City. This type of cooler is used with a closed system for cooling generator windings. Water is used as a cooling medium although the water does not come in contact with the air, since this is a surface type of cooler. The U-fins are used to increase the cooling surface and reduce the space required. In some cases the turbine condensate is used as the cooling medium and the condensate is increased about 10 deg. while on its way to the feed water heaters.

PHILLIPS EXPANSION JOINTS, which are built by the Henry Pratt Co., 2222 S. Halsted St., Chicago, are covered in Bulletin J-3. The Phillips expansion joint consists of two cast iron flange sections, rubber tube flexible element, adjustable sectional pressure plates and a water seal ring. Expansion joints of this type are used as a flexible connection between a steam turbine exhaust flange and its condenser. It is built in face to face dimensions of from 10 in. up. One of the joints illustrated in bulletin is 12 ft. 6 in. by 15 ft. and is for use with a 20,000-kw. turbine.

NORTON REFRACTORIES FOR HEAVY DUTY is the title of a 24-page booklet now being distributed by the Norton Co., of Worcester. The particular refractories described are known under the trade names of Alundum and Crystolon, and are designed for high temperature service. Information is given on the selection, use and properties of these refractories. Another booklet issued by this organization is on Norton porous plates, which are used in filtering work, in chemical, metallurgical and electrochemical operations, and for gas and air diffusion.

"SPAULDING FIBRE" is the title of a bulletin describing the processes used in making hard fibre which is now being distributed by the Spaulding Fibre Co., Tonawanda, N. Y. The bulletin also tells how to handle fibre when sawing, punching, turning, drilling and tapping it. Fibre of this type is used for condenser ferrules, gear blanks, truck wheels, panel boards and a wide variety of similar uses.

WESTINGHOUSE ELECTRIC and Manufacturing Co., East Pittsburgh, Pa., has recently issued a new publication known as Circular 1704, entitled Westinghouse Turbine Generators. Turbines from 500 to 6000 kw. are described and graphically illustrated. Various parts of Westinghouse steam turbines are described both as to construction and materials used in their manufacture. The solid steel rotor and how it is balanced; the lubrication system and how it functions; sealing glands and the part they play in steam turbine efficiency form interesting paragraphs in the new publication.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for Oct. 1, 1924.

State of Illinois,
County of Cook,
ss.

Before me, a Notary in and for the state and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:
Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill .

2. That the owners are: (If the publication is owned by an individual his name and address, or if owned by more than one individual the name and address of each, should be give below; if the publication is owned by a corporation the name of the corporation and the names and addresses of the stockholders owning or holding one per cent or more of the total amount of stock should be given.)
Technical Publishing Co., Chicago, Ill.
E. R. Shaw, Chicago, Ill.
A. L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgages, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)
There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is ..... (This information is required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 1st day of October, 1924.

E. C. Van Arsdel.

(My commission expires Feb. 16, 1928.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the postoffice. The publisher must publish a copy of this statement in the second issue printed next after its filing.